NEW ZEALAND MARINE DEPARTMENT

FISHERIES TECHNICAL REPORT
NO. 40

TUNA INVESTIGATIONS - EAST COAST AREA OF NEW ZEALAND 1965 - 1967

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WELLINGTON, NEW ZEALAND

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FISHERIES DIVISION
WELLINGTON

PLATE 1. F.V. "AKINA"

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SUMMARY

Investigations to assess the commercial viability of gill-netting, supplemented by trolling for albacore and skipjack tuna from a 45' vessel during the summer seasons of 1965-1967 was carried out by the Fisheries Division, Marine Department, in association with the Fishing Industry Board.

The survey area was the east coast of the North Island from Mahia Peninsula to Whale Island.

Catch rates for the principal method of gill-netting were 11.40; 4.7; and 2.14 fish per net/hour in 1965-1967 respectively.

The trolling catch rates were 3; 46; 10. fish per 100 hook-hours. The highest catch rate being 800 per 100 hook-hours in 1966 off the Waiapu River mouth, when three vessels landed 600 albacore during 5 hours' trolling.

Hydrological measurements were taken, and biological information on albacore and skipjack, including length and weight frequency, food, maturity.

TUNA INVESTIGATIONS EAST COAST AREA OF NEW ZEALAND

1965 - 1967

INTRODUCTION

Each year albacore (Thunnus alalunga) and skipjack, or striped bonito (Katsuwonus pelamis), migrate into New Zealand waters between December and May. The generalized migratory pattern of these fish is illustrated in Figure 1. For many years individuals of these species have been caught around the New Zealand coastline, most frequently around North Island between latitude 35° and 40°S (Figure 2).

Following the introduction of sophisticated artificial lures in 1955, big game fishing boats operating from the Bay of Plenty to the Bay of Islands made tuna catches usually of yellowfin (Thunnus albacares), but occasionally of southern bluefin (Thunnus maccoyii), albacore or skipjack.

In 1963 the Marine Department investigated the basic patterns of temperature and salinity in relation to the distribution and migrations of tuna in coastal waters; log sheets and thermometers were issued to fishermen whose observations supplemented the Marine Department's technical staff's field work.

In 1964 a commercial fishing vessel was chartered by the Marine Department to investigate the fisheries potential of the southern bluefin tuna in the Fiordland Sounds area on the south west coast of the South Island. Although many scattered schools were sighted, bad weather restricted fishing and only ten southern bluefin averaging 60 lbs. weight were landed.

From 1965 to 1967 the potential viability in East Coast areas of a tuna fishery based on gill-netting supplemented by trolling from vessels about 45-50 feet in length was investigated. The investigations were financed by the Fishing Industry Board and carried out by the Marine Department technical staff. The area investigated and place-names mentioned in the text are shown in Figure 32.

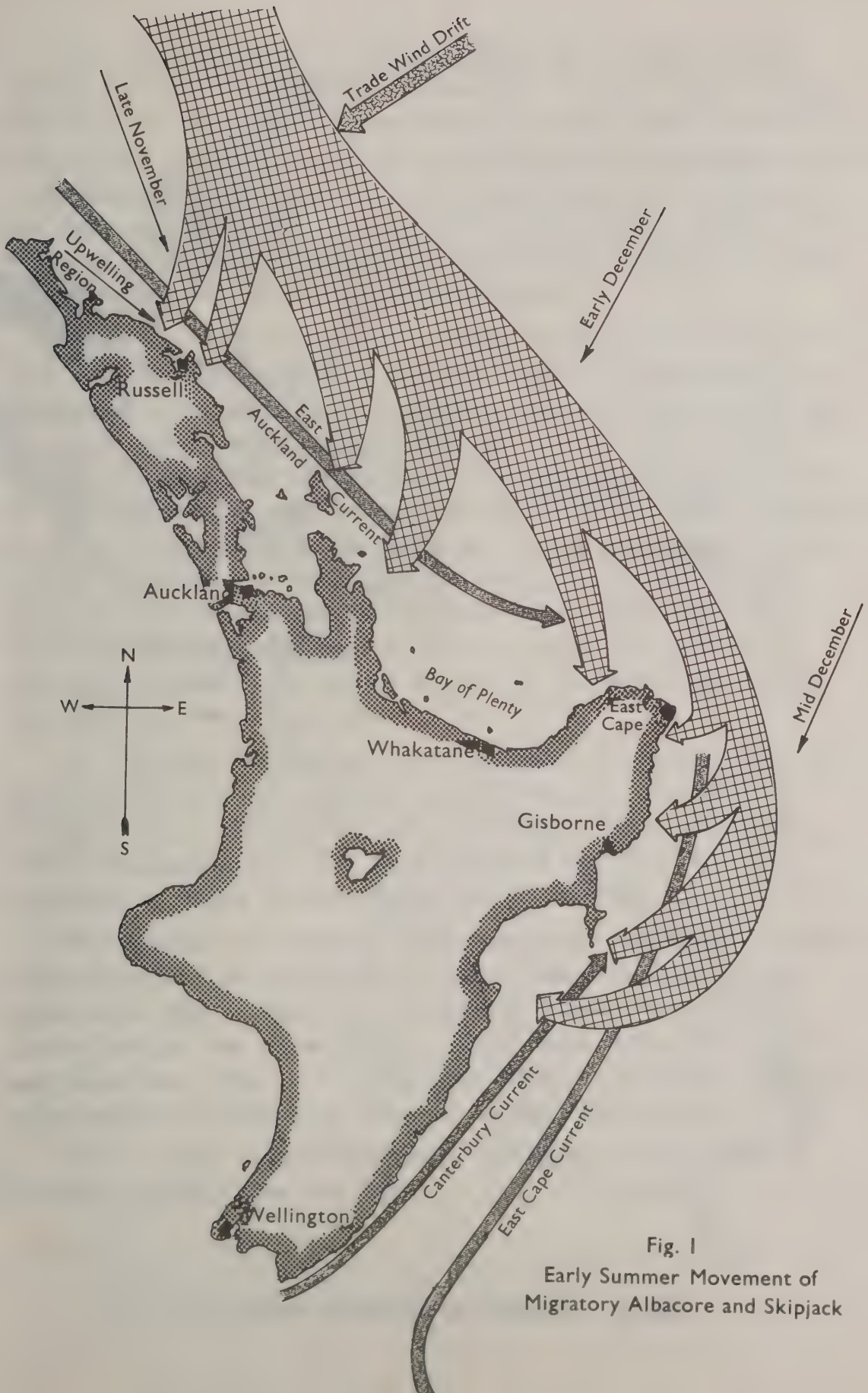


Fig. 1
Early Summer Movement of
Migratory Albacore and Skipjack

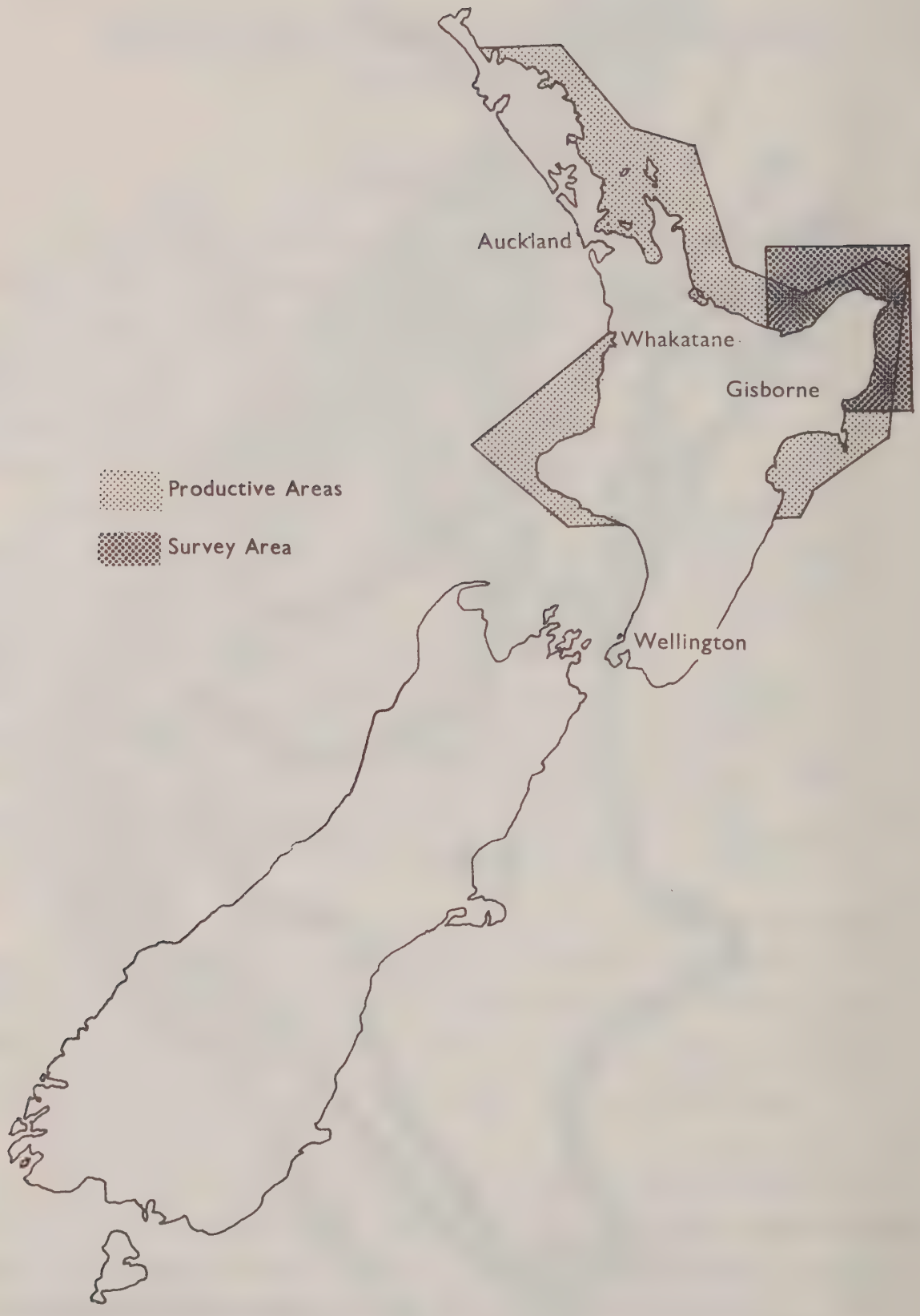


Fig. 2 Productive and Survey Areas

In 1965, following a demonstration of fishing methods by the Japanese at Tauranga in the Bay of Plenty, gill-netting and trolling techniques suitable for use from small vessels in New Zealand coastal waters were developed and hydrological and other observations associated with the occurrence of albacore and skipjack recorded. During this project which lasted from February to April, hydrological and fishing surveys were made in the area from Gisborne to Cape Runaway.

From the data collected in 1965, it was decided that in each year the starting date for the fishing survey would be determined from the results of a preliminary hydrological and trolling survey early in the year and that a further hydrological and trolling survey should be carried out at the end of the season when tuna became scarce. From the data collected in 1965, it was decided to begin the 1966 preliminary survey in mid-February. However, unlike 1965, the albacore began schooling off the Waiapu River mouth before mid-February. The skipjack schooling period was from April to late May, and this resulted in a survey period of 96 days. The survey area was the same as in 1965.

In 1967 the preliminary surveys began in January before the albacore started to school and fishing continued until mid-May. The survey period was 137 days but the post-season survey was cancelled. The area surveyed was from Mahia Peninsula to Whale Island in the Bay of Plenty.

The surveys of 1966 and 1967 simulated commercial fishing operations with gill-netting as the primary fishing method. Lures were trolled when on passage and intensive trolling carried out in the areas where catches were made. Gill nets were shot when schools of tuna were seen, or whenever trolling indicated the presence of tuna on or near the surface.

This report records the data collected in the investigations of 1965, 1966 and 1967.

EQUIPMENT AND METHODS

GENERAL

(a) Vessels:

The vessels "Trade Wind", "Seastar" and "Akina" were chartered for the 1965 surveys and "Akina" for 1966 and 1967. The "Akina" is shown in Plate 1 (Frontis-piece).

The use of a "Sono-Buoy", a floating cannister containing a hydrophone, audio amplifier and radio transmitter, operating between 67.7 and 71.7 MHz, showed that the "Seastar" and "Akina" were free from irregular low frequency noises, such as those from loose propellor shafts and slack rudder gear, which have a marked scaring effect on some fish, particularly skipjack. "Trade Wind" was not checked.

(b) Navigation:

The vessel's position was fixed precisely by using sextant horizontal angles, or land transits, these angles being transferred to a chart by a protractor. The charts used, BA 2577 and NZ 56, were divided into grids of approximately two square miles to facilitate reference plotting. (Figure 3).

(c) Fish-Finder:

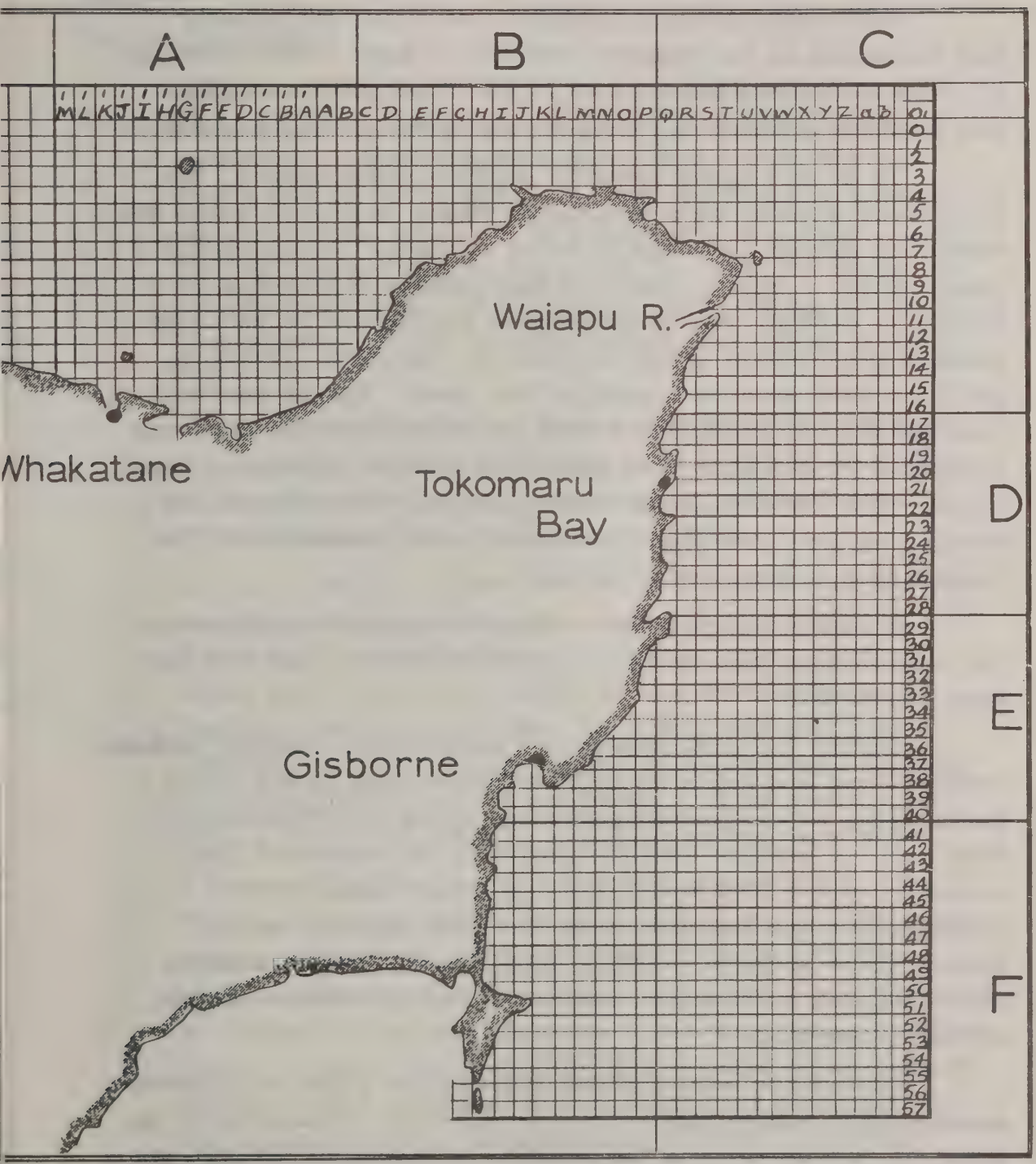
A Furuno 0-200 fathoms dry paper recording fish-finder was used to detect the depth and nature of the bottom, the presence of scattering layers, and fish in the surface and near-surface layers.

The "Sono-Buoy" was used to detect near-surface schools of tuna and also, from time to time, to determine whether tuna were meshed in the gill-nets.

(d) Logs:

Daily log sheets were kept incorporating all relevant data including meteorological data, sightings of school fish, mammals and birds, or other biological phenomena.

FIG. 3. AREA GRID



HYDROLOGY

From March 1965, a portable induction salinometer was installed on the charter vessels to give direct readings of temperature and salinity. In the field the instrument was frequently checked. Recalibration was rarely necessary.

To obtain close interval surface measurements, the cell was suspended in a 20 gallon wooden drum into which sea water was pumped directly from the surface. Tests within a range of 16° - 21° C. showed a temperature difference of 0.02°C. - 0.06°C. but no detectable difference in salinity between the surface water and that in the drum. Vertical profiles were made to depths of 400 feet. When a vertical profile was required, the vessel "hove to" and the cell was lowered over the side with the cable running through a metre block. The vertical temperature profiles were frequently checked against readings from a reversing thermometer; no significant discrepancies occurred.

A standard 0-900 feet bathy-thermograph supplemented the salinometer when vertical profiles deeper than 400 feet were required.

During the preliminary and post-season surveys vertical temperatures and salinity profiles were made in the Ariel Banks area, at designated positions along the Continental Edge, and at various inshore positions to ascertain the average depth of the thermocline and the stability of temperatures and salinities in the near surface layers. During these surveys, surface temperatures and salinities were recorded at about 15 minutes (i.e. approximately two miles) intervals.

During the main fishing survey, the interval between measurements was lengthened to approximately 35 minutes (5 to 6 miles) but whenever a temperature or salinity "front" was encountered, or tuna were present, sufficient observations were made for the pattern of isotherms and isohalines to be clarified. At most settings of the gill nets vertical profiles were taken.

FISHING

(a) Trolling:

Various patterns of trolling rigs were tried in 1965. The most efficient was the "Hawaiian" rig (Figure 4) modified so that the shortest lines are on the outboard end of the outriggers, and the longest line is on the stern, as shown in Figure 4A. A second light rubber shock absorber was added to take the shock of skipjack strikes; when heavier tuna strike the lure, the stronger shock absorber takes the strain (Figure 4B).

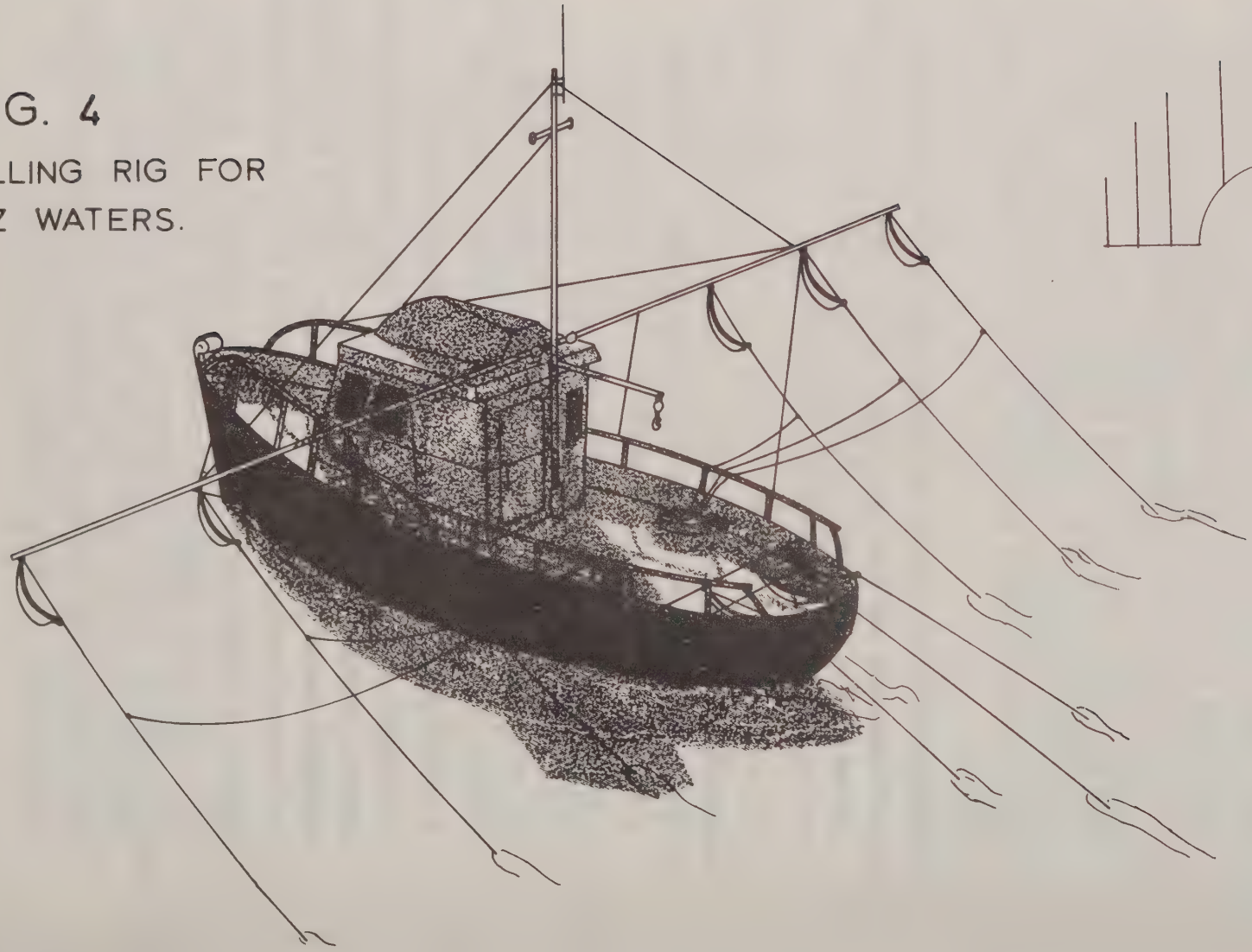
The outriggers shown in Figure 4 were of galvanised iron piping 20 feet in length with a swivel base to allow easy adjustment when trolling and horizontal or vertical stowage while gill-netting.

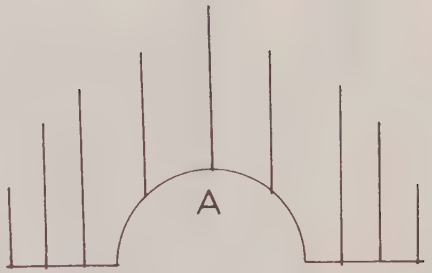
Nylon or proplin lines from 30 to 60 feet long with a breaking strain of 900 lbs., were used for the main lines from the outriggers to the traces. (Lighter lines were tried but tended to cut the hands when hauling heavy tuna.) The lines were spliced into a 350 lbs. breaking strain swivel and the trace secured to the outboard end of the swivel. Nine foot nylon traces of 150 to 250 lb. breaking strain were used.

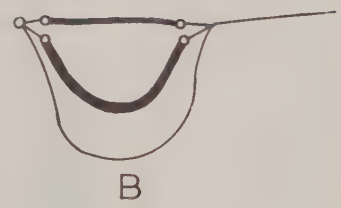
A variety of lure types and colours were tried, e.g. "Killwell No. 5" lures of opaque red, white, green and grey plastic with barbless hooks, Japanese tinted plastic lures resembling squid and octopus and modified by strengthening the hook trace and using twin barbless hooks, a similarly modified lure resembling an anchovy. The lure used depended on the colour of the water and the general weather conditions. Several lures were weighted so as to fish six or eight feet below the surface. This minimised the danger of lures becoming tangled when altering course.

FIG. 4

TROLLING RIG FOR N.Z WATERS.







A Japanese "Haritsuki Hobiki" paravane with a feather jig lure and 150 metres of line was used when possible, and this type of deep trolling gear was supplemented by a locally constructed ball type paravane.

During the 1965 and 1966 preliminary and post-season surveys, nine lures were streamed, i.e. three from each outrigger and three from the stern (see Figure 4) but in 1967 only four lures were used. During the fishing survey nine lures were used whenever conditions were suitable for trolling.

Based on observations made during the years the optimum trolling speed for albacore is five to seven knots and for skipjack seven to eight knots, but both species were hooked at speeds from two to ten knots, and many fishermen confirmed landing albacore and skipjack at speeds up to 15 knots.

Whenever a strike was made the trolling speed was maintained even while the fish were hauled inboard (Plate 2) until no further strikes were made.

The fishing method varied according to the behaviour of the tuna school. If a large school appeared to be moving in a set direction, the vessel approached on a tangential course and trolled around the fringe of the school until it sounded or no further strikes were made; but if the tuna were in scattered small schools the vessel trolled through the schools.

When strikes were made by tuna feeding several fathoms below the surface, trolling carried on without alteration of course until no further strikes were made; the vessel then steamed back on a reciprocal course and continued trolling in this manner until the tuna sounded or left the vicinity.

When striped marlin (Makaira audax) or yellow fin tuna were present, several lures were secured to a buoy, which in turn was secured to the stern by a light nylon trace. When the fish took the lure, the nylon trace parted and the buoy carried overboard to remain floating until the vessel recovered it with the fish.

PLATE 2. Landing Albacore at Trolling Speed.

Immediately before gill-netting the lures were taken inboard and triced on the gunwale well clear of the netting operations. They were again streamed immediately the gill nets were secured.

(b) Gill-netting:

Colourless monofilament nylon gill-nets were used. For albacore nets 160 yards long by 80 meshes deep with a 7½ inch mesh were used; for skipjack the nets were 160 yards long and 150 by 5½ inch meshes deep. Both types had ground lines with 76 separate lead weights, until the latter part of the 1966 survey when they were replaced by ground lines with a continuous lead core. Cork lines had 53 spaced floats. In 1967, several large "Line Fishing" buoys were added for extra flotation and to increase net visibility.

Gill-nets were carried at all times and several techniques were tried, e.g. shooting the nets where the hydrological conditions appeared good or shooting through a school of tuna but after March 1965 the technique of shooting the nets in a crescent ahead of schools (Figure 5) was mainly used. In 1967, several attempts were made to anchor the nets across the tide; the nets were streamed with approximately five fathom gaps between them. The results of these modifications are discussed later (Page 77). Hauling and shooting of the nets was generally by hand but from 9 to 23 February 1965 and 19 March to 9 May 1967 a powered reel was used.

In 1965 the reel was mounted approximately twelve feet from the stern on a wooden platform so raising the point of hauling above the horizontal guide roller. The reel was operated hydraulically from a four cylinder pump which, in turn, was driven by a petrol engine on the deck as shown in Figure 6. The petrol engine was so noisy that a field telephone was used for communication between the skipper and the reel operator. In 1967 the powered reel and an unmeshing roller were then fitted close to the stern, but the petrol engine was not used, the hydraulic pump being installed in the

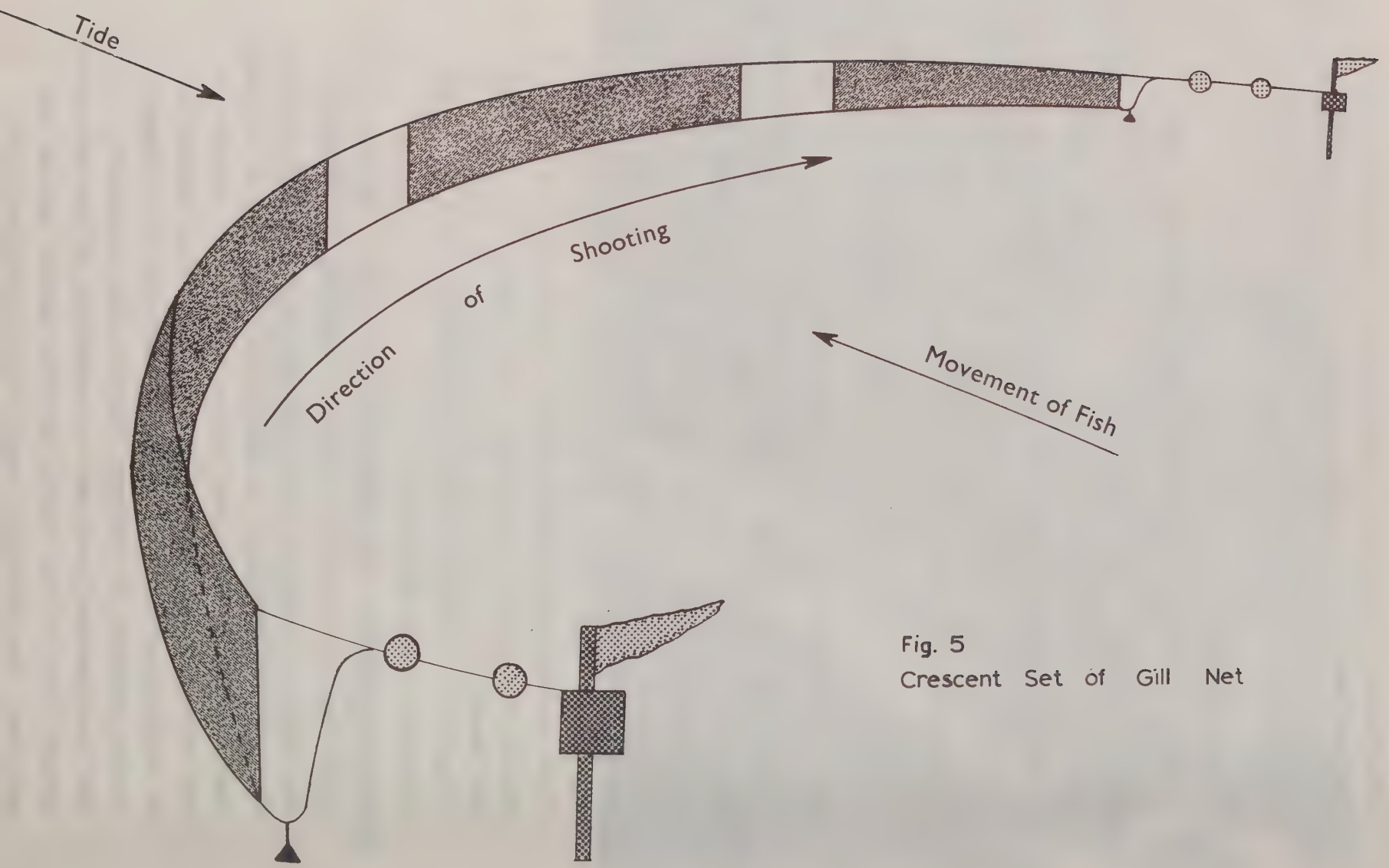


Fig. 5
Crescent Set of Gill Net

engine room and driven from the main engine; this eliminated the excessive noise on the upper deck and gave a more stable reel speed. The winch operator, at position 3 in Figure 6, controlled reel direction by a lever, and reel speed with a valve. The two crew members, in positions 1 and 2, were responsible for streaming the buoys and tending the net during shooting, guiding the net on to the reel when hauling, and unmeshing the catch.

In shooting, the reel was put out of gear (in the free-running position) and when a school of tuna was found the nets were shot across the tide at a speed of 2 to 3 knots ahead of the school at a position which allowed sufficient time for the vessel to be clear and the net to sink before the fish reached them. Usually several nets were used. (See Plate 3 and Figures 5 and 7). If the reel over-ran or extra buoys were required, the vessel was slowed by putting the engine out of gear.

After shooting, the vessel remained within sight of the nets to observe any marked dipping of floats due to fish caught or spiralling of the nets caused by tides. After a suitable time or when dipping floats indicated a good catch, the vessel approached the gill-nets up-wind or tide (whichever was the stronger) and "hove to" clear of the net (Figure 8) but sufficiently near to heave a grapnel around the buoy line (Figure 8 (a)). As the buoy was being taken on board and passed to the stern, the vessel slowly altered course down-wind (Figure 8 (b)) and the cork and ground lines were secured to the reel for hauling (Figure 8 (c)).

The engine was then taken out of gear and the vessel, being anchored to the net, lay stern into the wind, thus ensuring that it would not over-ride the net and foul the propellors. During hauling the crew fed the cork and ground lines on to the reel, unmeshed the catch, and ensured that the belly of the net did not foul the propellors.

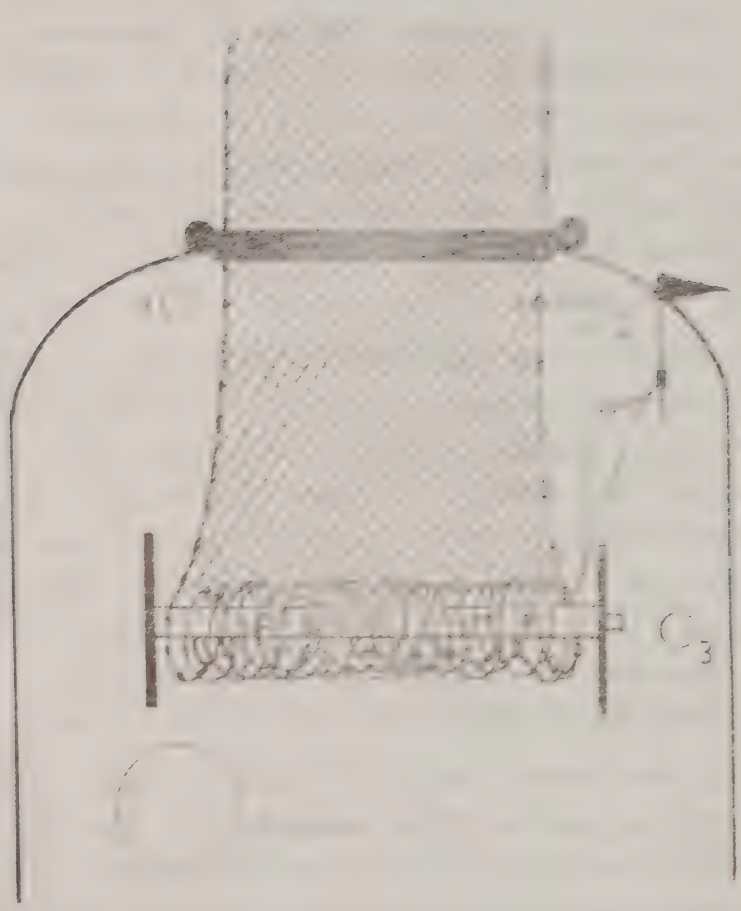


Fig. 6 Shows Detail for Gill Netting by Power Reel

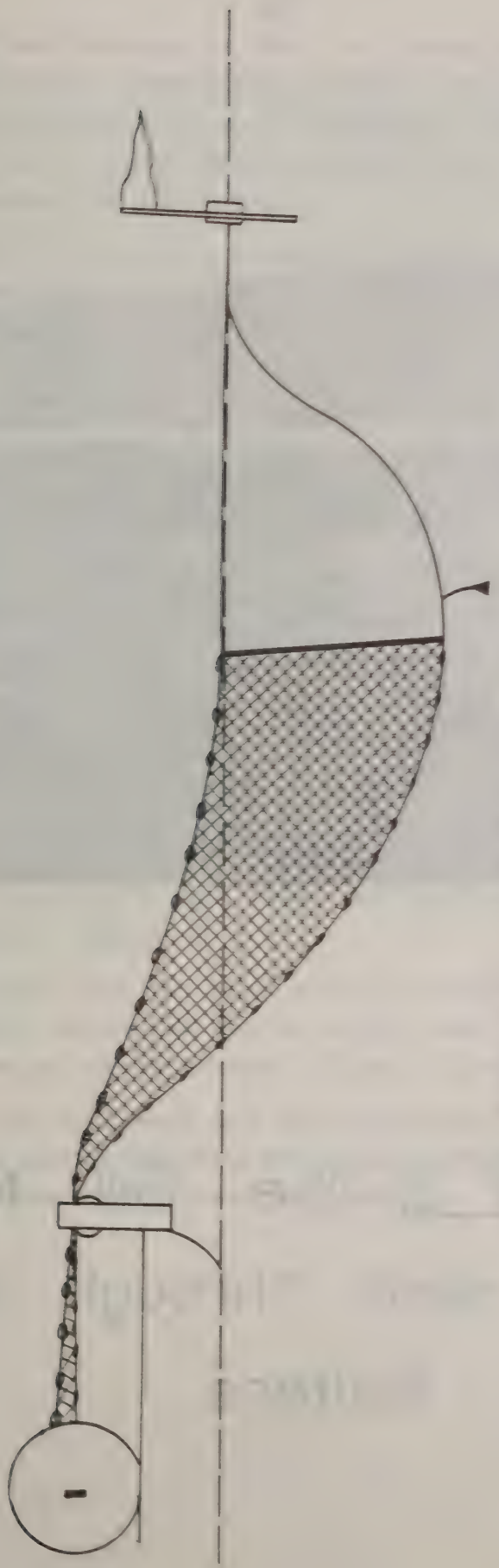


Fig. 7 *Shooting Gill Net by Powered Reel*

PLATE 3. The Gill Net being shot through Stern Rollers.

In shooting and hauling by hand the techniques were the same as described above with some minor variations. No expensive modifications, such as wooden platforms and large horizontal and vertical guide rollers, were made to the structure of the vessel.

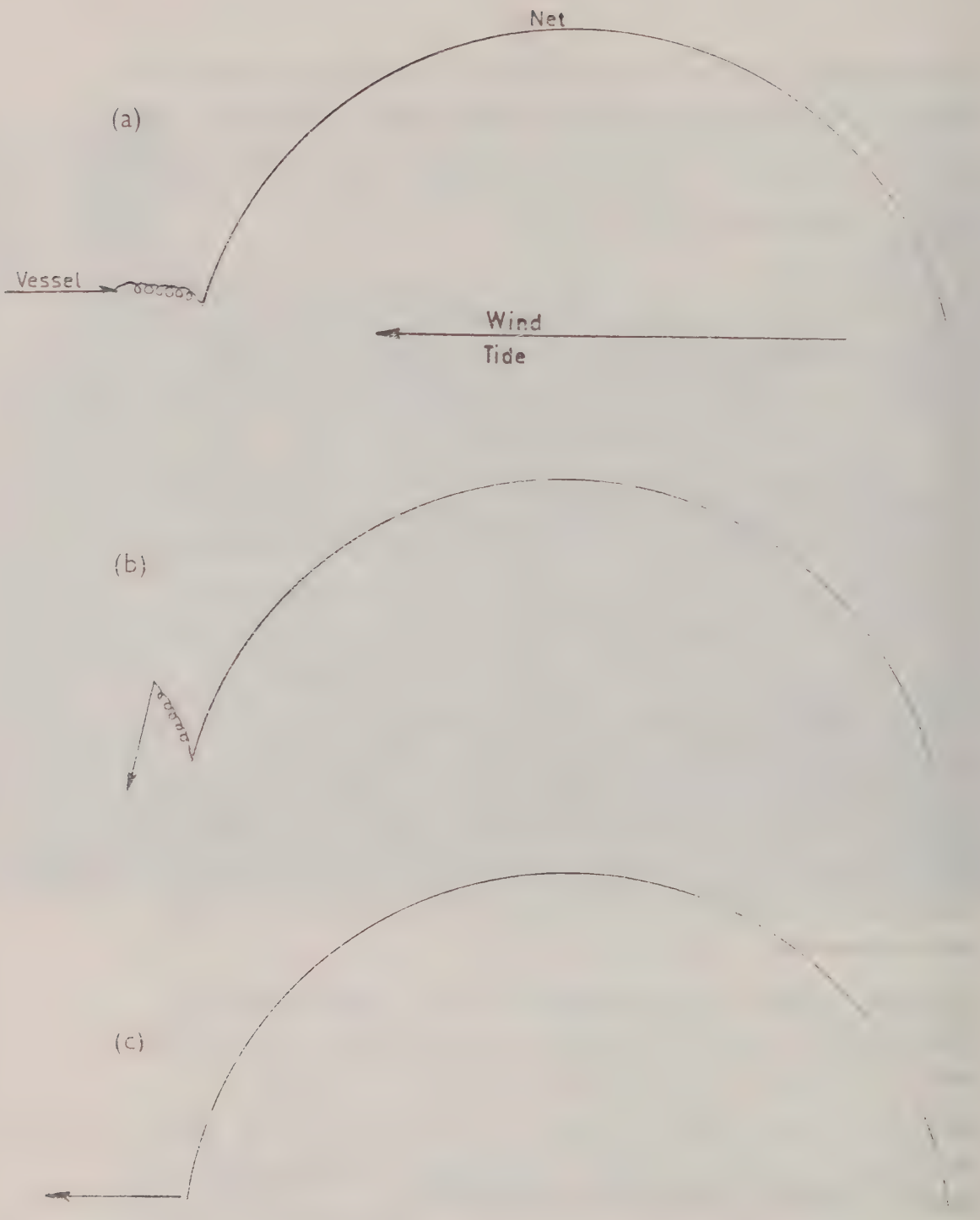
All obstructions on the stern were covered with canvas to ensure smooth running of the gear. The nets were laid on a canvas sheet on the after-deck, the cork line coiled on one side, the ground line on the other and the belly of the net in the centre. The belly was springy and bulky, but several sacks laid on top of each net effectively reduced this bulk. Buoys and ground weights were secured before shooting (Figure 9).

During shooting the skipper remained at the helm and the two crew members tended the cork and ground lines and removed the damp sacks as necessary (Plate 4).

During hauling with the vessel stern to the wind and out of gear the skipper tended the belly of the net and helped to unmesh the catch, but was ready at all times to manoeuvre the vessl if required. If many fish were meshed close together the ground line was temporarily secured to the stern post whilst the fish were unmeshed. (Plate 5)

Three men could fish two nets without undue physical strain, but an extra man was necessary when using more nets or in wind forces between 12 and 17 knots.

After the last haul each day the nets were hosed down to clear any phyto-plankton stain and covered with canvas as protection against sunlight.



(a) Approach and Recovery of Bouy Line

(b) Securing of Bouy Line

(c) Positioned for Hauling

Fig. 8 Gill Netting

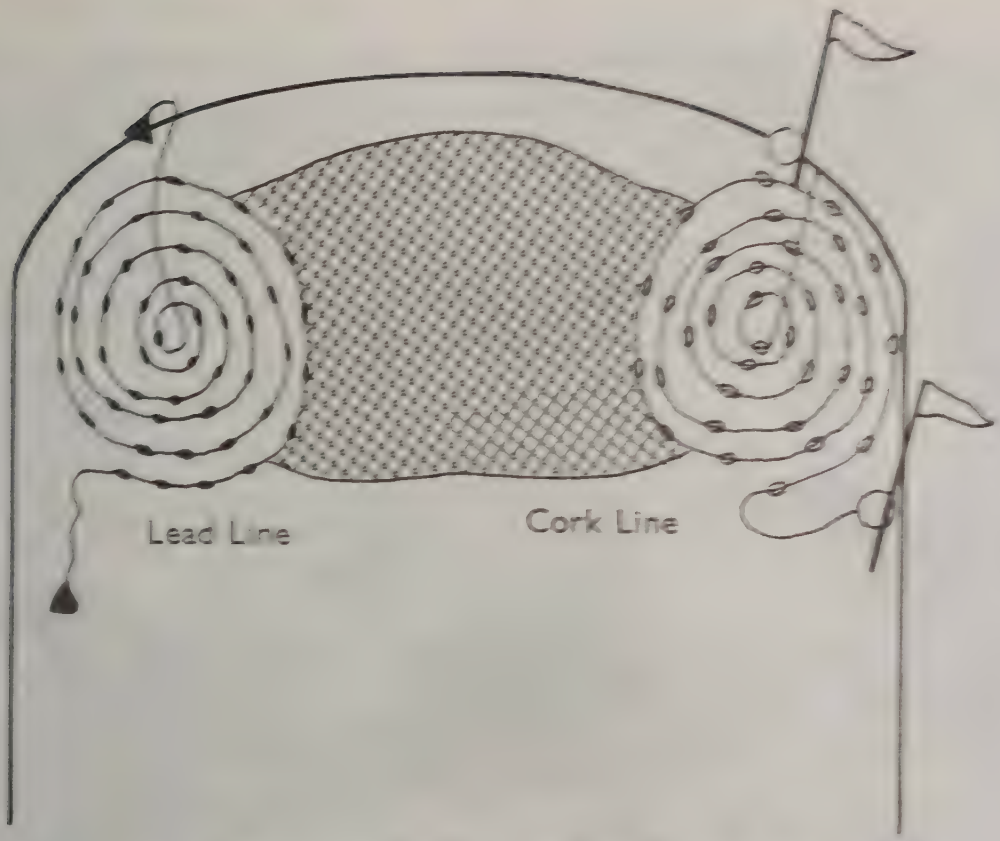


Fig. 9 Shows Detail for Gill Netting by Hand

PLATE 4. Shooting the Gill Net by hand.

EXAMINATION OF FISH

During fishing the tuna captured were placed under canvas to protect them from the sun, and later counted, weighed and measured (snout to caudal fork). These measurements were recorded together with time and position of capture, and relevant hydrological and meteorological data.

The gonads of five per cent of the fish were examined and meristic counts were made on three per cent of the fish. Stomach contents were also examined.

The work was carried out on a 45 foot vessel and on occasions no data could be recorded due to weather conditions and some small inaccuracies in weighing were unavoidable. Accurate weighing in harbour revealed that the maximum weight error was $\pm$ 2%.

RESULTS

HYDROLOGY

Table 1 shows the maximum and minimum sea surface temperatures and surface salinities observed during the survey.

In Figure 10 the average of the surface temperature and salinity observations made in each month are plotted for each year. Figure 11 and 12 show the isotherm and isohaline patterns in February 1966, and Figures 13 and 14 show the pattern of isotherms and isohalines in January 1967.

Figures 15 to 22 show the hydrological conditions from February to April-May 1967 in particular areas where fishing was carried out. They include observations made over only an eight day period and when the pattern in Figures of the same area in the same month differ, e.g. Figures 20 and 21, also 16 and 17, this is because they relate to different time periods.

On Figures 15 to 22 the heavy black numbers represent the number of tuna caught in the best catch or catches made in that area and time period. The position of other and smaller catches made within the same area and time period is not indicated.

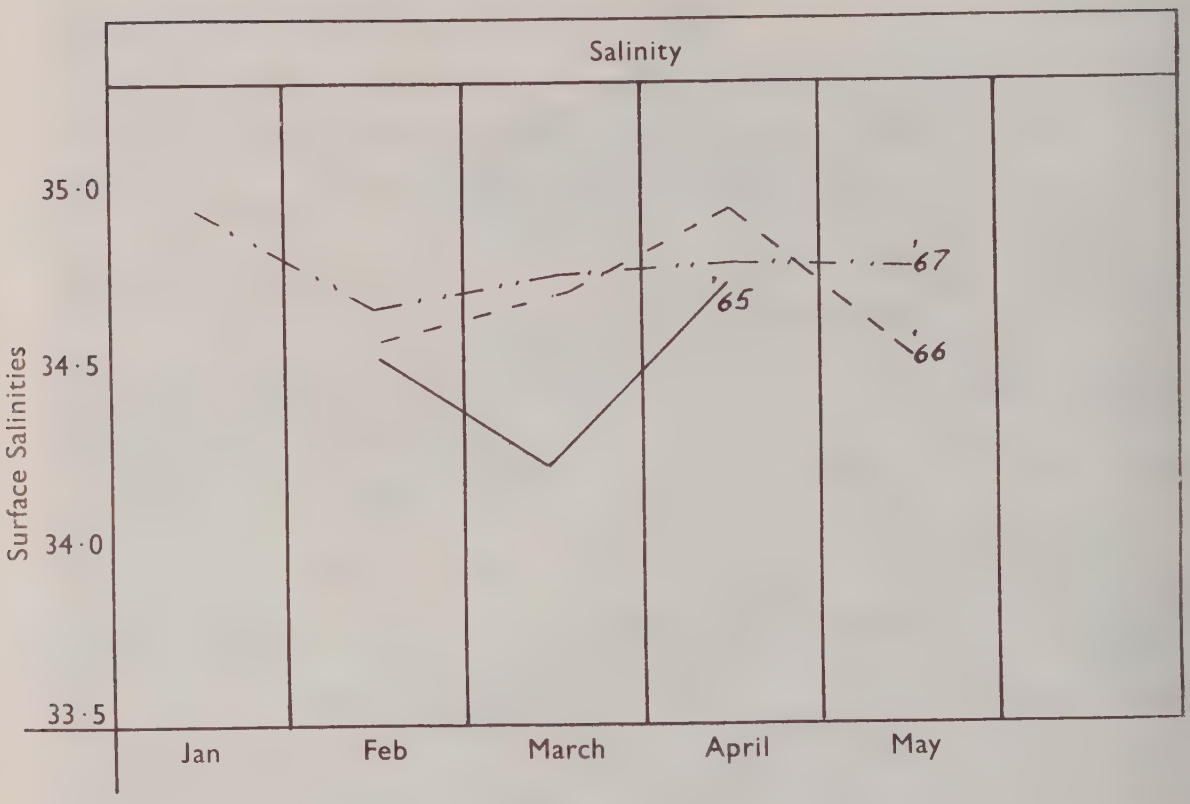
PLATE 5. Ground Line secured to stern post whilst unmeshing Skipjack.

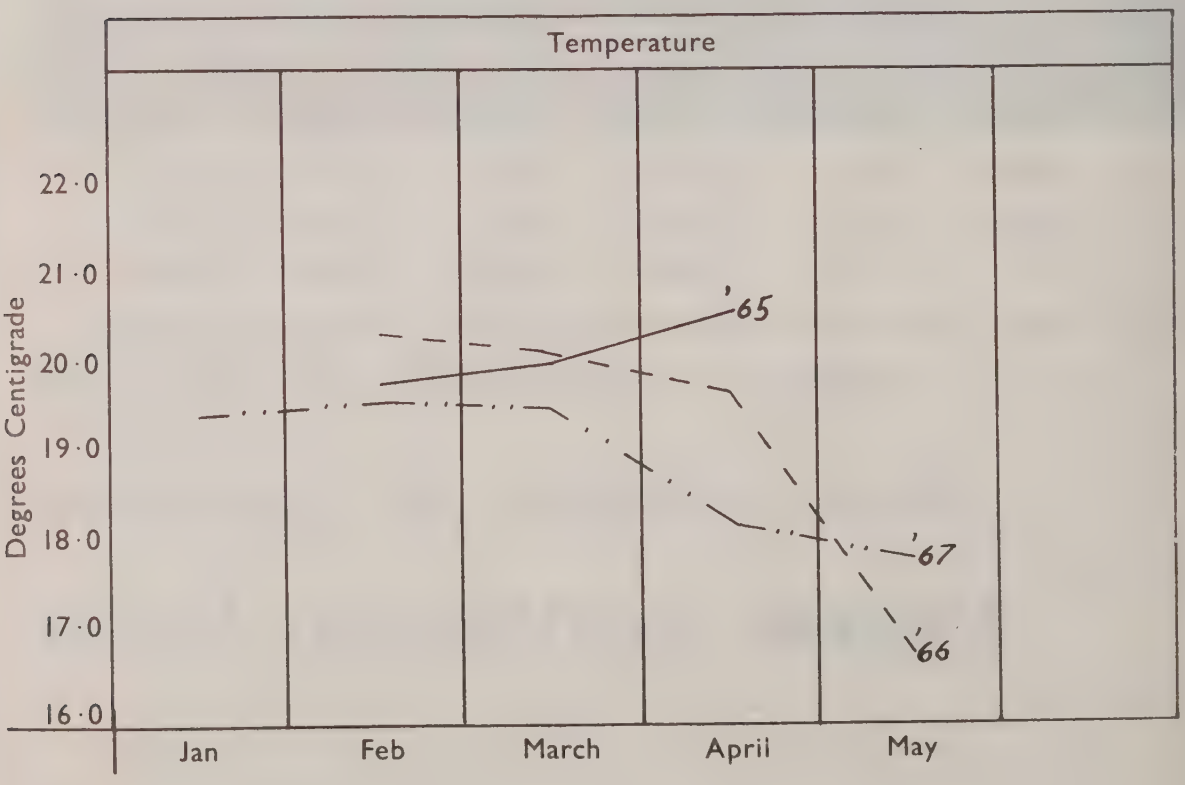
TABLE 1

Maximum and Minimum Sea Surface Temperatures and Salinities Recorded During the Surveys.

Month		Number of Observations	Temperature °C		Salinity °/oo	
			Minimum	Maximum	Minimum	Maximum
1965	Feb.	250	16.4	21.3	33.7	34.9
	March	235	16.5	21.3	33.4	35.2
	April	390	17.3	20.6	34.1	35.1
1966	Feb.	135	17.9	22.4	33.5	35.2
	March	240	18.3	22.2	31.3	35.3
	April	186	17.1	20.8	34.0	35.5
	May	45	14.7	19.3	32.3	35.2
1967	Jan.	365	13.8	21.4	34.7	35.5
	Feb.	260	16.4	22.4	34.4	34.9
	March	101	16.7	21.7	34.7	35.1
	April	177	16.3	20.2	34.2	35.1
	May	69	16.5	18.5	34.1	34.9

Fig. 10 Monthly Temperature and Salinity Averages





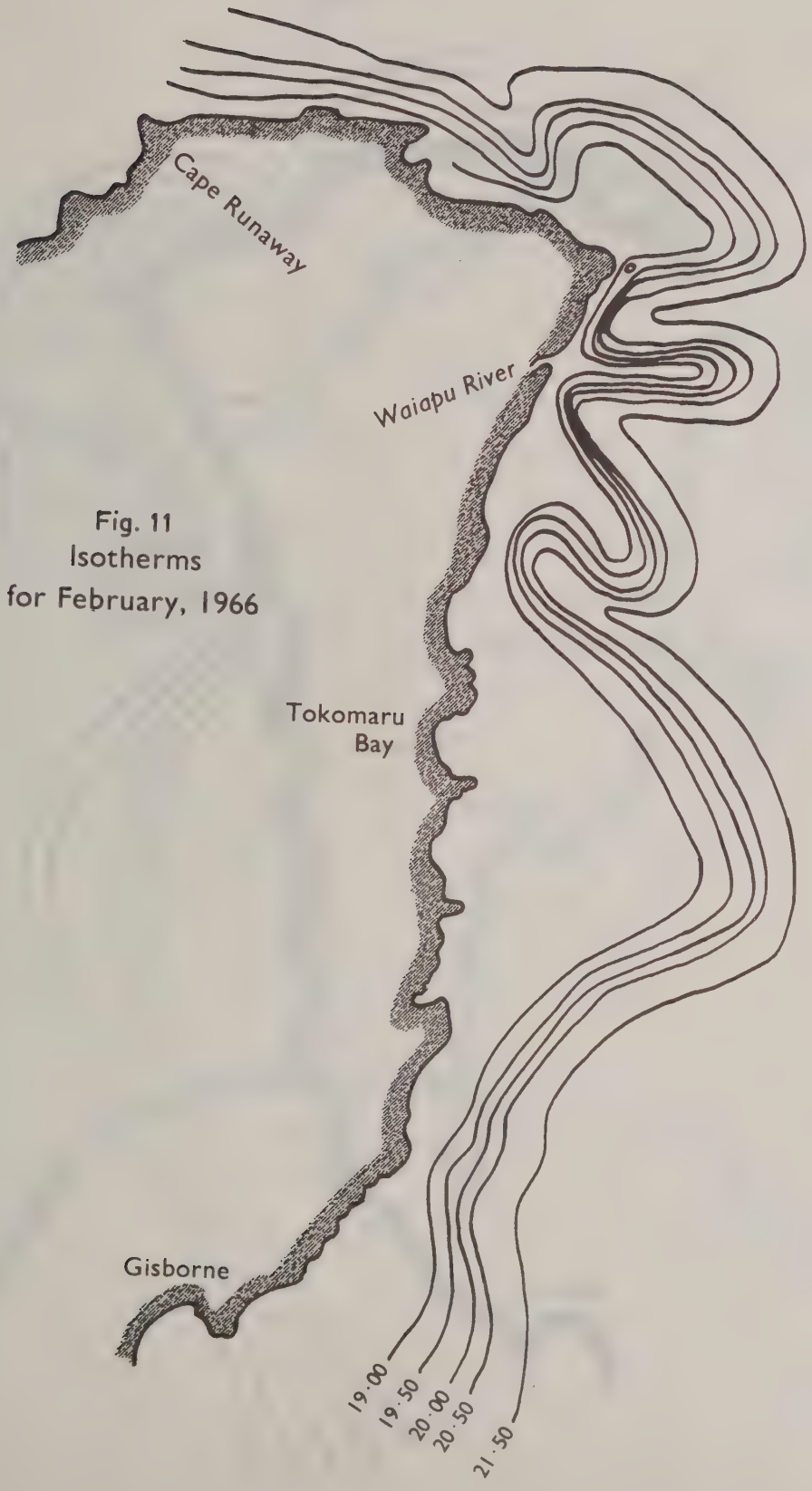


Fig. 11
Isotherms
for February, 1966

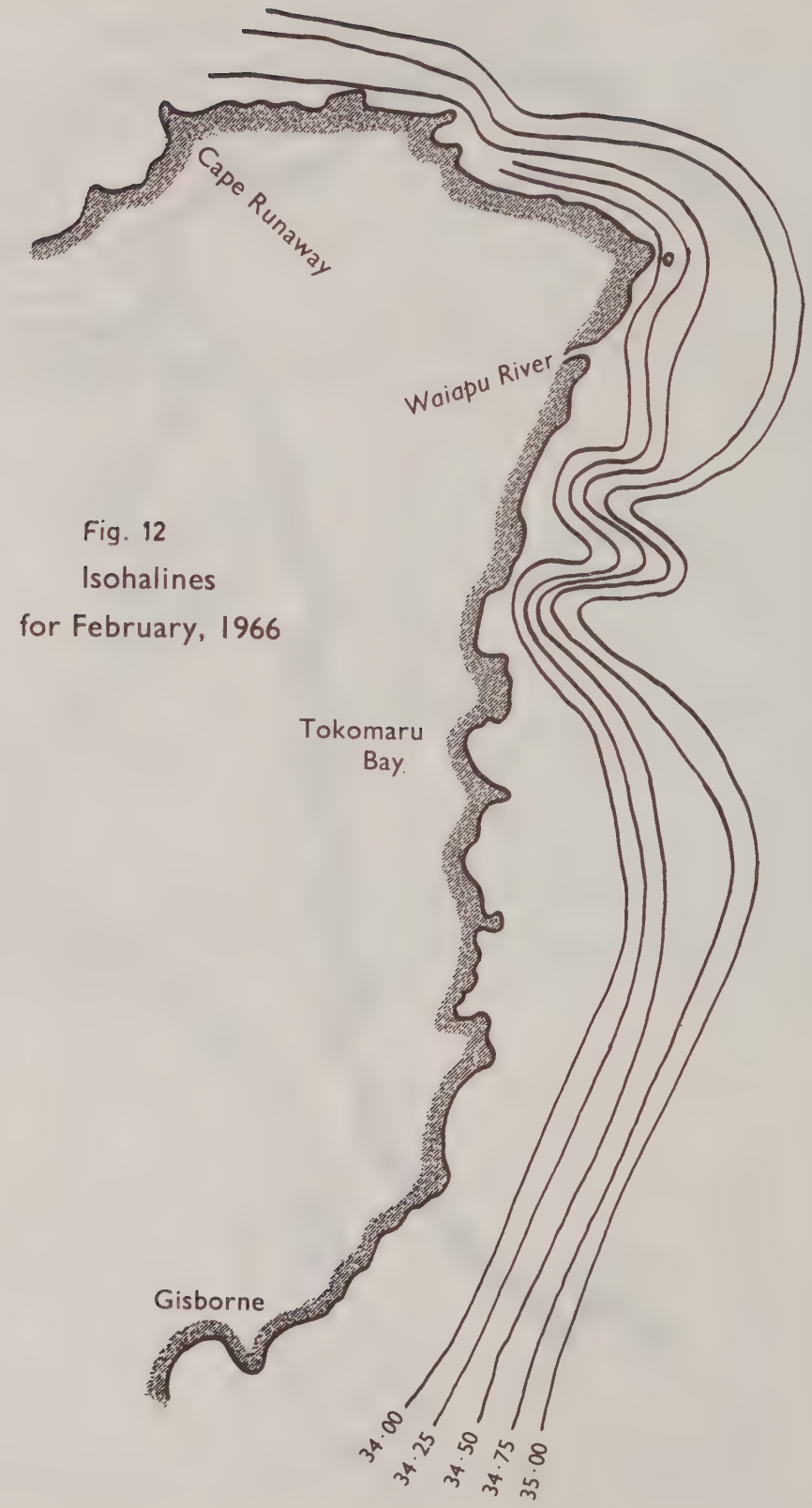


Fig. 12
Isohalines
for February, 1966

Fig. 13
Isotherms
for January, 1967

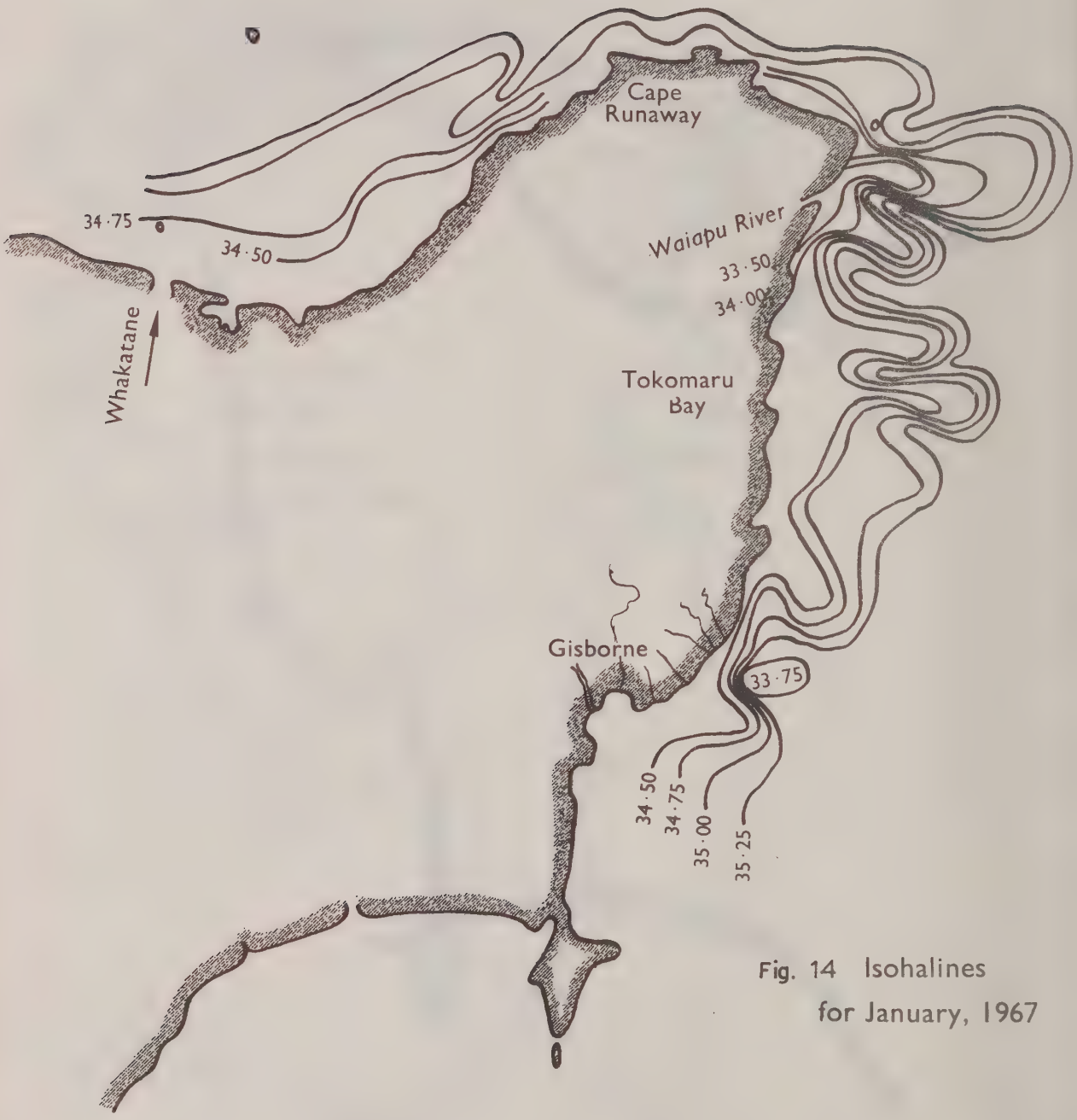


Fig. 14 Isohalines
for January, 1967

Fig. 15 Trolling
Surface Isotherms, February 1967

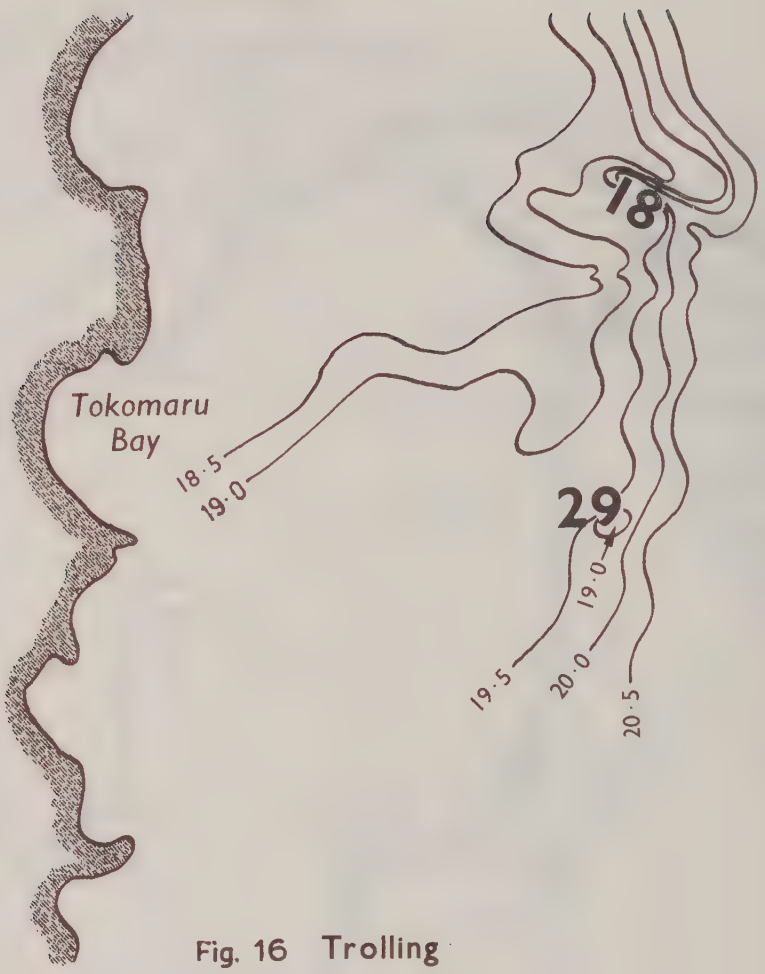


Fig. 16 Trolling
Surface Isotherms, February 1967

Fig. 17 Gill Netting
Surface Isotherms, February 1967

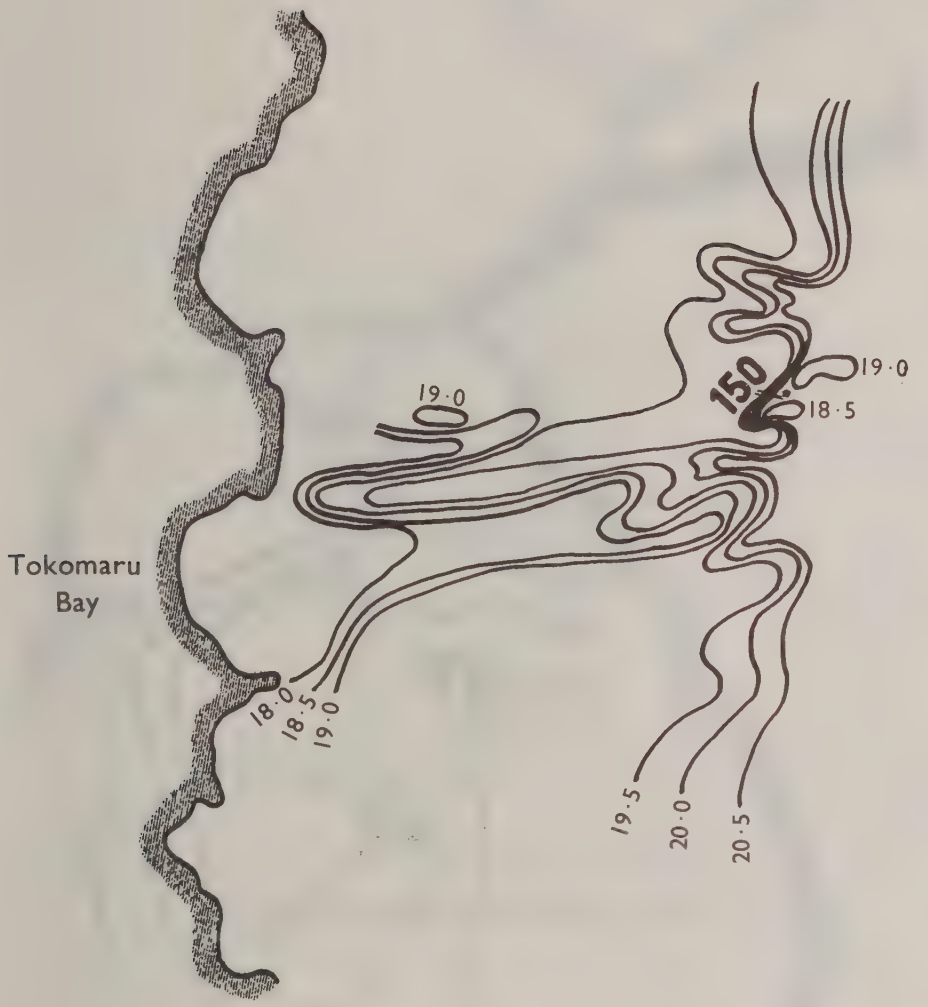
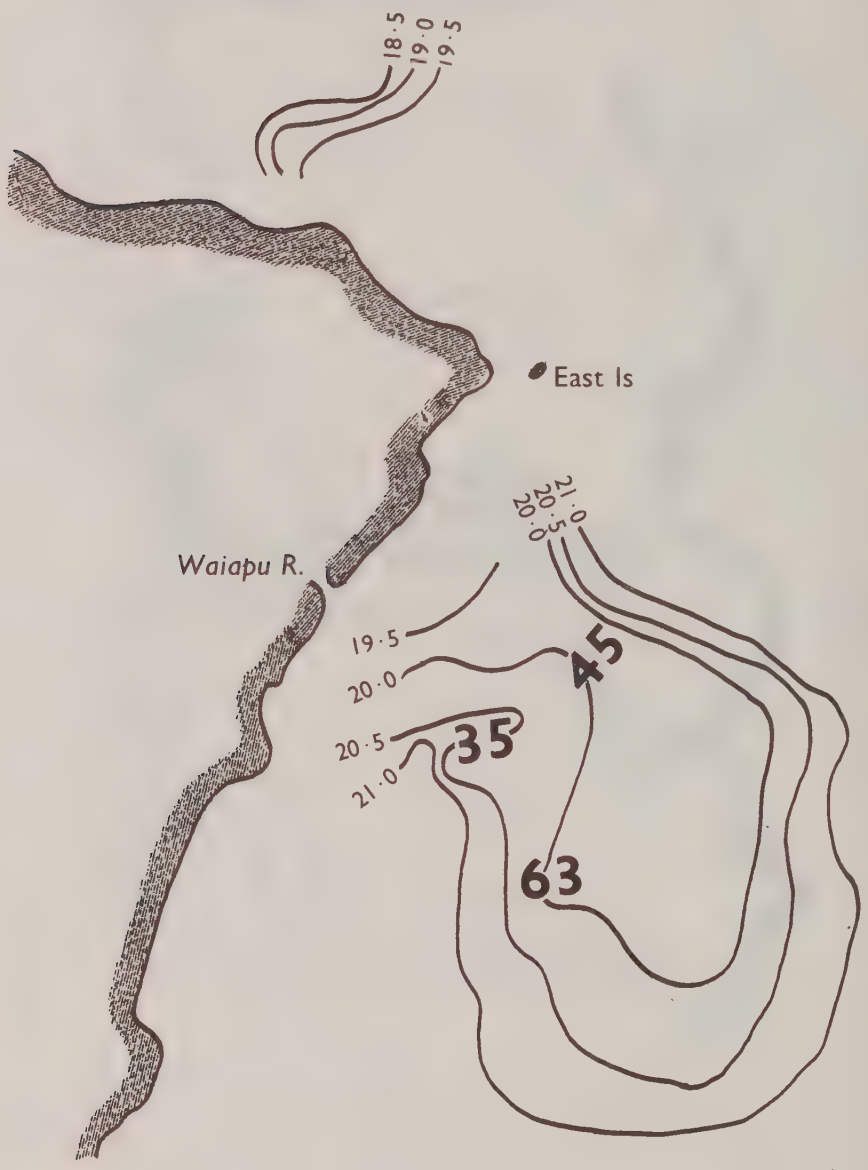
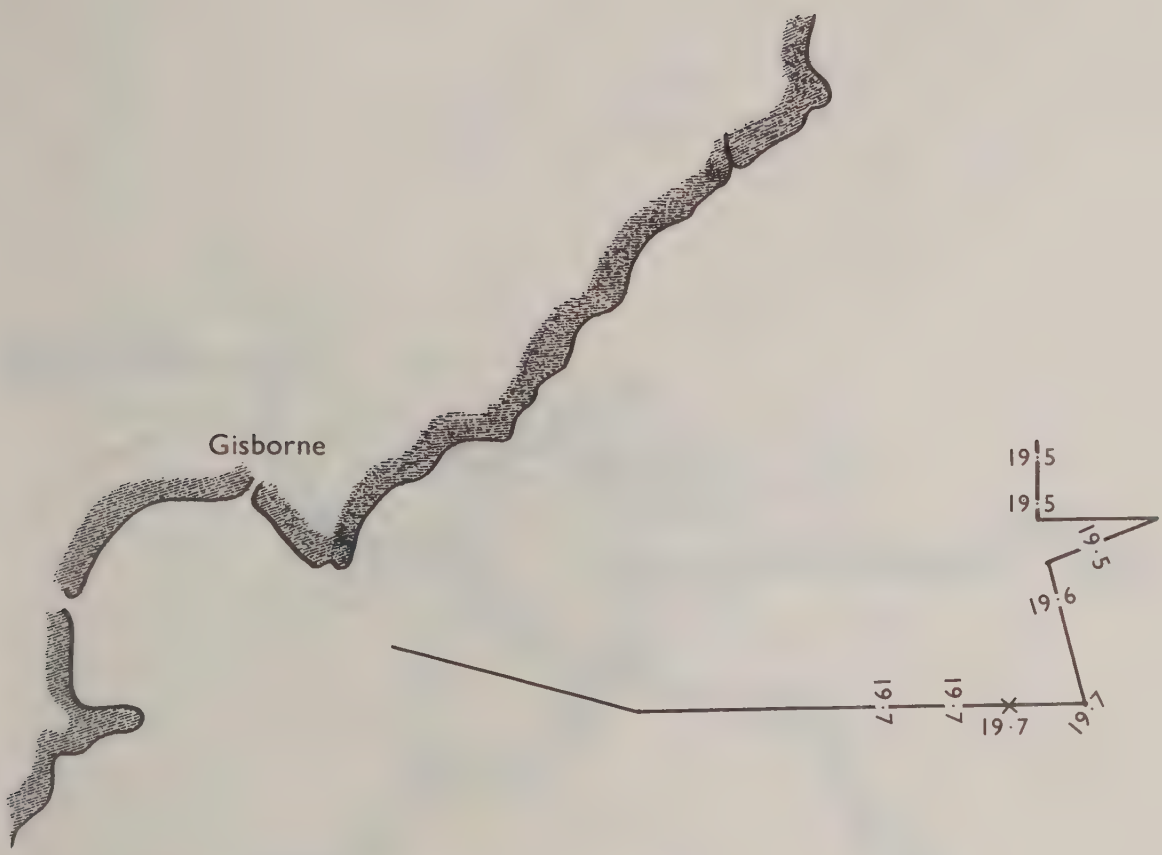


Fig. 18 Trolling. Surface Isotherms, February 1967



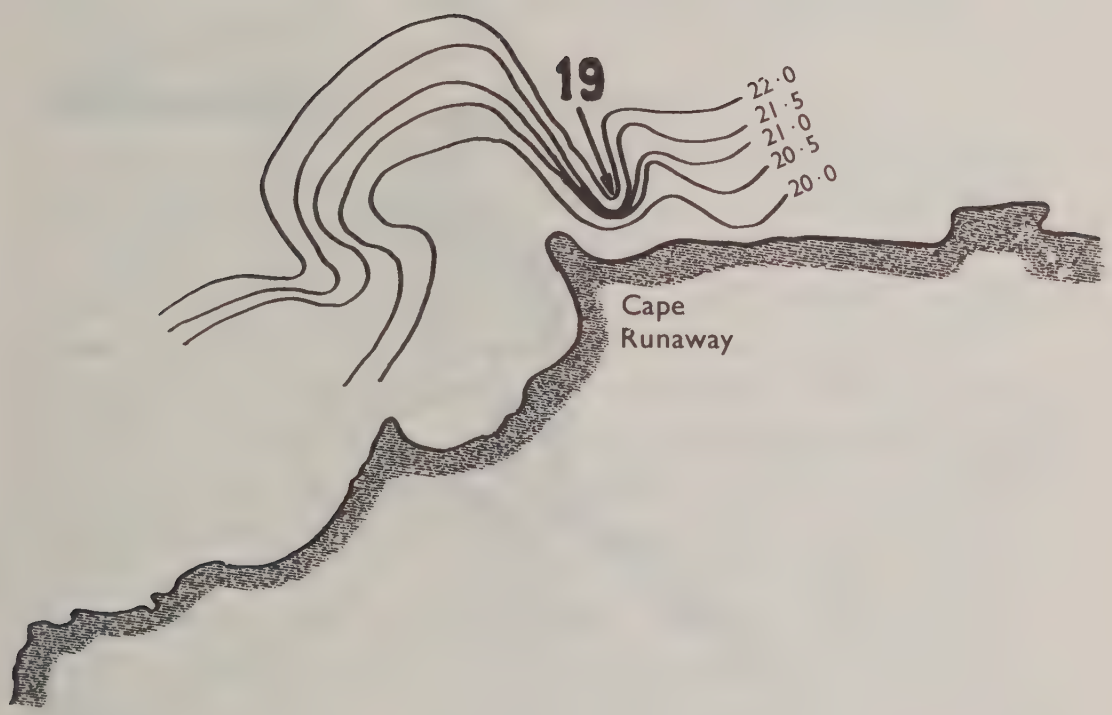


× = Position of Gill Net. Catch 98 Tuna

Fig. 19 Gill Netting
Surface Temperatures, March 1967

Fig. 20 Gill Netting
Surface Isotherms, March 1967

Fig. 21 Trolling
Surface Isotherms, March 1967



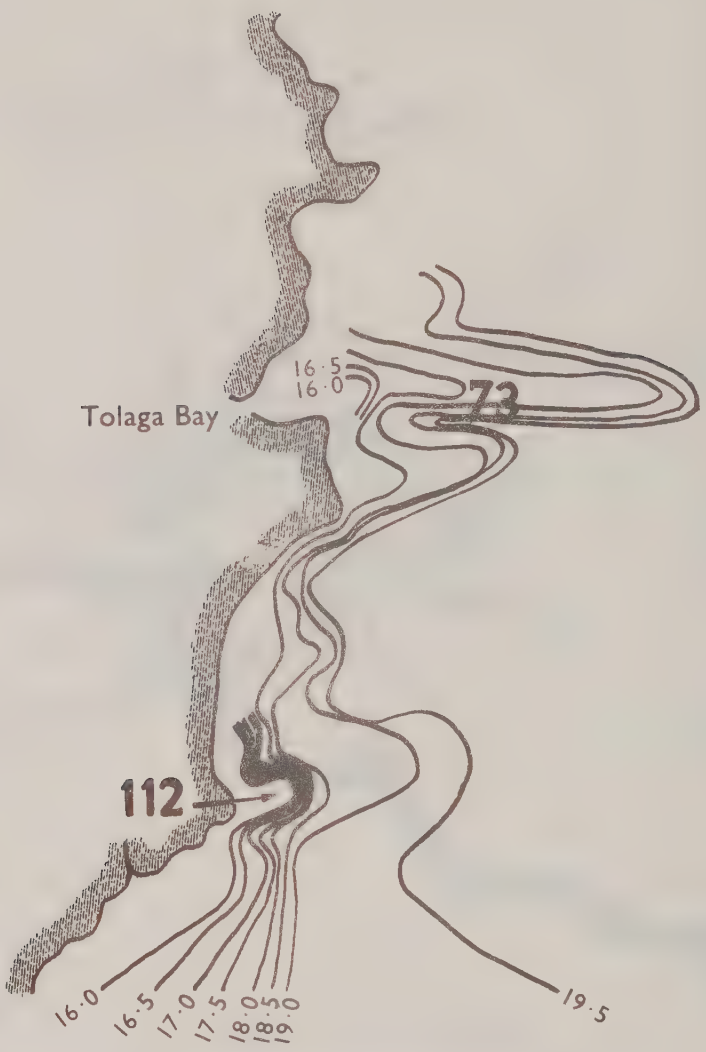


Fig. 22 Gill Netting
Surface Isotherms, April-May 1967

Insufficient hydrological data was obtained for a full isometric pattern to be plotted in Figure 19; the track of the vessel and observations made are shown.

The general hydrological pattern in the area is of increasing temperature and salinity with distance offshore interrupted by tongues of low temperature and low salinity off river mouths.

The hydrological patterns observed in each year are discussed below.

(a) 1965 Survey

In 1965 much of the survey period was used in defining gross hydrological differences in the area rather than in evaluating isotherm and isohaline patterns.

A total of 875 surface temperatures was taken. During February around Cape Runaway the average temperature was 20.9°C, elsewhere average temperatures were 19.3°C - 19.9°C. In March the lowest average temperature (18.7°C) occurred near the Waiapu River, and the highest (20.9°C), in the Tolaga Bay area; elsewhere temperatures were 18.9°C - 19.1°C. In April average temperatures were: Waiapu River 16.8°C, Ariel Banks 17.5°C, Cape Runaway 18.1°C, Tokomaru Bay 18.7°C, East Cape 19.5°C and at Tolaga Bay 19.8°C. Figure 10 shows an overall average temperature range in 1965 of 4.9°C, and the average salinity range of 1.5°/oo, with a very little difference between months. Thermoclines occurred at an average depth of 37 metres, between Ariel Banks and Tokomaru Bay and at 90 metres near White Island.

(b) 1966 Survey

Table 1 and Figure 10 show that the maximum and average surface temperatures for each month except April were higher in 1966 than in 1965. In May temperatures fell steadily from 19.3°C to 14.7°C and the average for the month was 16.7°C.

Between Tolaga Bay and Tokomaru Bay, the termocline was at 100 to 200 metres, but in the East Cape area its average depth was 200 metres.

The isotherm pattern for February (Figure 11) shows typical conditions in the Waiapu River area when the East Cape Current is weak. The river's influence extends in a narrow tongue for several miles out to sea, with warm "fronts" to the north and south. Salinities were fairly stable. Lower salinities occur off river mouths, such as the Waiapu River south of East Cape and indicates an area of mixing between fresh water run-off and offshore water.

Figure 12 shows the southward transport of mixed low saline water from the Waiapu River by the East Cape Current as two small tongues to the south of the river mouth.

(c) 1967 Survey

In early January low surface temperatures occurred in the Hicks Bay area and the 14°C and 15°C isotherms extended for several miles westward towards Cape Runaway. Figure 13 shows the more complex pattern of surface temperatures from Tolaga Bay to Cape Runaway, with warm tongues extending towards the shore at Tolaga Bay, Waiapu River mouth and Cape Runaway. From Cape Runaway to Whakatane temperatures were higher and relatively stable.

The area of very low salinity to the east of Gisborne in January (Figure 14) is probably of fresh water origin either from a spring or the numerous small coastal rivers between Gisborne and Tolaga Bay. Hydrological conditions in February are shown in Figures 15 - 18 together with fishing data (in large figures) where appropriate. In March the Bay of Plenty to Cape Runaway area had a higher temperature range than the coast between Gisborne and East Cape (Figures 19-21). In Figure 22 the cooling of inshore temperatures at the end of April is shown by the 16°C and 17°C isotherms being present within one and two miles of the coast.

Isothermal conditions were present from the surface down to 100 metres. The highest average temperatures were in area A, (Figure 3). These were about 19.9°C until the end of March. From April to mid-May temperatures decreased from 19.5°C to 17.8°C. In area B highest average temperatures were in March and April. Lower average temperatures occurred in area E in all months except February when temperatures were below in area F.

The highest temperature recorded was 22.4°C in the eastern end of the Bay of Plenty in February; and the lowest temperature of 13.8°C was measured off Matakaoa Point, Hicks Bay, in January. Average salinity ranged from 34.69 to 34.96°/oo.

FISHING

A total of 1,054 hours was spent trolling during the three surveys and 1,152 tuna (mostly albacore) were caught.

A total of 143 hours gill netting over the same period caught 1,897 tuna (mainly skipjack). The total catch of 3,049 tuna weighed 29,818 lbs. green weight. Detailed catch data are shown in Tables 2 to 11.

(a) Trolling:

During the 1965 survey, 21 albacore and 12 skipjack were landed during 287 hours of trolling (Table 2) at a catch rate of 3 fish per 100 hook hours and in 1966 (Table 3) over a period of 190 hours, 619 albacore and 73 skipjack were landed (46 fish per 100 hook hours). In 1967 (Table 4) the trolling time was 577 hours and the catch was 399 albacore and 28 skipjack (10 fish per 100 hook hours).

Albacore catch-rates were highest in February each year and skipjack highest in March-April (Figures 23 and 24).

Table 5 compares the catch-rates of the various lures used in 1966 and 1967; although there is some difference between the years "Killwell No. 5 Green", the plastic fish, plastic squid and feather jig were the more successful lures and "Killwell No. 5 Grey" and "Knucklehead" were poor.

(b) Gill-netting:

Catch rates in 1965, 1966 and 1967 were 11.40, 4.70 and 2.14 fish per net-hour respectively.

In 1965, 65 albacore (weight 1,080 lbs.) and 433 skipjack (weight 2,600 lbs.) were netted in 11.75 fishing hours. Tables 6 and 7 include data on the gill-netting carried out in 1965. It can be seen that in 1965 gill-net catches were best after mid-March and in general fishing was best in areas B and C. The albacore gill-netted in area B on 26 March should also be noted - no other large catches of albacore were made by gill-netting.

In 1966, 22 albacore and 703 skipjack were netted in 48.5 fishing hours. Tables 8 and 9 include data on gill-netting carried out in 1966. Few albacore were gill-netted and these mostly in March. Skipjack gill-netting was most successful from 23 to 28 March and from 21 April to 7 May. The poor catches from 28 March to 19 April were due to a combination of change of fishing area and inclement weather. Table 9 shows that catches were generally highest in areas C and E. No tuna were caught in the 7½" mesh gill-net.

In 1967, 9 albacore and 665 skipjack were netted in 83 fishing hours. Fishing data is shown in Tables 10 and 11. In 1967, the few albacore netted were all caught in February in 7½" mesh nets. Skipjack catches were good on 18 and 24-26 February, 19 March, 12 and 25 April and 7 May but catch rates were generally poor. Best fishing areas were areas D and E (Table 11). Figure 25 shows albacore gill-net catches in 1966 and 1967. Figure 26 shows skipjack catches in both years were high in April and catches were also good in February 1967.

TABLE 2

1965 TROLLING CATCHES (lbs. not numbers of fish) per 100 Hook-hours

Period	Trolling Hours	Hook Hours	Total Catch (lbs)		Catch 100 Hook-Hours	
			Albacore	Skipjack	Albacore	Skipjack
2-9/2	28	56	14	-	25	-
9-23/2	63	126	153	-	121	-
8-27/3	105	420	54	-	13	-
2-16/4	91	728	132	70	18	10
TOTAL:	287	1,330	353	70	27	1

TABLE 3

1966 Trolling Catch per 100 Hook-Hours (Number not Weight of Fish)

Period	Trolling Hours	Hook Hours	Total Catch		Catch 100 Hook-Hours	
			Albacore	Skipjack	Albacore	Skipjack
19-26/2	52	468	386	9	82	2
2-16/3	51	459	135	19	29	4
17-30/3	42	368	95	31	26	8
1/4-6/5	45	171	3	14	2	8
Totals and Mean Catch-Rate	190	1,470	619	73	42	5

TABLE 4

1967 Trolling Catch per 100 Hook-Hours (Number not Weight of Fish)

Period	Trolling Hours	Hook Hours	Total Catch		Catch 100 Hook-Hours	
			Albacore	Skipjack	Albacore	Skipjack
3-13/1	70	308	20	-	6	-
14-22/1	51	421	41	-	10	-
26/1-2/2	71	639	19	-	3	-
7-19/2	78	841	81	3	10	1<
21/2-1/3	87	801	194	5	24	1<
13-19/3	58	447	27	7	6	2
31/3-2/4	22	198	12	-	6	-
6-19/4	71	637	4	12	1<	2
21/4-11/5	71	174	1	1	1<	1<
Totals and Mean Catch Rates	579	4,466	399	28	9	1

TABLE 5

Comparison Between the Catch-Rates of Different Trolling Lures.
(Number of fish per 100 Lure Hours) (Lures streamed for equal periods)

Catch per 100 hook-hours

Lure	Albacore		Skipjack	
	1966	1967	1966	1967
"Killwell No. 5 Red"	17	1	2	3
"Killwell No. 5 White"	10	8	2	1
"Killwell No. 5 Green"	95	12	15	1
"Killwell No. 5 Grey"	-	5	-	-
Plastic Squid	56	6	5	1
Plastic Fish	121	5	12	1<
Feather Jig	21	21	2	1<
"Knucklehead"	2	-	-	-

TABLE 6

Gill-Netting 1965

Date	Nets Used No. and Mesh Size		Hours Fished	Net-Hours	Catch (in lbs.)		Lbs/net hour
	5½"	7½"			Albacore	Skipjack	
15/2/65	4	-	4.0	16	-	200	12.5
9/3/65	4	-	0.5	2	0	0	0
10/3/65	4	-	1.5	6	0	0	0
14/3/65	4	-	1.0	4	0	0	0
14/3/65	2	2	1.25	5	0	0	0
21/3/65	2	1	Net lost	-	-	-	-
26/3/65	2	1	0.75	2.5	1,080	0	432
4/4/65	2	1	1.0	3	0	1,600	533
10/4/65	2	1	0.5	1.5	0	200	133
10/4/65	2	1	1.25	3.37	0	600	178
TOTAL:	-	-	11.75	43.75	1,080	2,600	-

TABLE 7

1965 Gill Netting in Each Area : Areas Shown in Figure 3

Catches in lbs.

Area	Nets Used No. and Mesh Size		Hours Fished	Net-Hours	Catch (in lbs.)		Lbs/net hour
	5½"	7½"			Albacore	Skipjack	
B	2	1	0.75	2.5	1080	-	432
C	2	1	1.0	3.0	-	1600	533
D	4	0	4.0	16.0	-	200	12.5
E	18	4	6.0	22.25	-	800	36

drift netting 1958. No fish were caught in the 7½ mesh. * Overnight set.

Date	Nets Used No. and Mesh Size		Hours Fished	Net Hours	Catch (number of fish)		Number of Fish Net-Hour	
	5½"	7½"			Albacore	Skipjack	Albacore	Skipjack
13/3	3	1	1.5	6	0	11	0	1.8
14/3	3	1	1.25	5	0	3	0	0.6
23/3	3	1	1.0	4	0	43	0	10.7
26/3	3	1	1.25	5	9	52	1.8	10.4
28/3	3	1	1.75	7	5	71	0.7	10.0
29/3	3	1	2.5	10	10	10	1.0	1.0
2/4	3	1	2.0	8	6	11	0.75	1.4
3/4	3	1	0.25	1	0	2	0	2.0
4/4	3	1	2.0	8	0	5	0	0.6
11/4*	0	1	12.0	12	0	0	0	0
12/4	3	1	1.0	4	0	0	0	0
14/4	4	0	3.5	14	0	9	0	0.6
19/4	4	0	4.0	16	1	2	0.6	1.2
21/4	4	0	3.75	15	0	174	0	11.6
21/4	4	0	2.5	10	0	108	0	10.8
22/4	4	0	1.5	6	0	60	0	10.0
24/4	4	0	1.75	7	0	72	0	10.3
24/4	2	0	1.0	2	0	13	0	6.5
25/4	4	0	3.0	12	0	31	0	2.6
7/5	2	0	1.0	2	0	26	0	13.0
8/5	1	0	0.25	0.25	0	0	0	0
TOTAL			48.5	154.25	22	703		

TABLE 9

1966 Gill-Netting in each area (Areas shown in Figure 3) - Catch as no. of fish

Area	Nets Used No. and mesh size		Hours Fished	Net Hours	Catch (No. of Fish)		No. of Fish Net/Hour	
	5½"	7½"			Albacore	Skipjack	Albacore	Skipjack
A	6	2	2.75	11.0	0	14	0	1.3
B	13	2	7.75	28.25	0	40	0	1.4
C	15	6	19.75	43.0	21	146	0.5	3.4
E	29	1	18.25	72.0	1	503	0	7.0

TABLE 10

Gill-Netting 1967. * = 23 hour shot

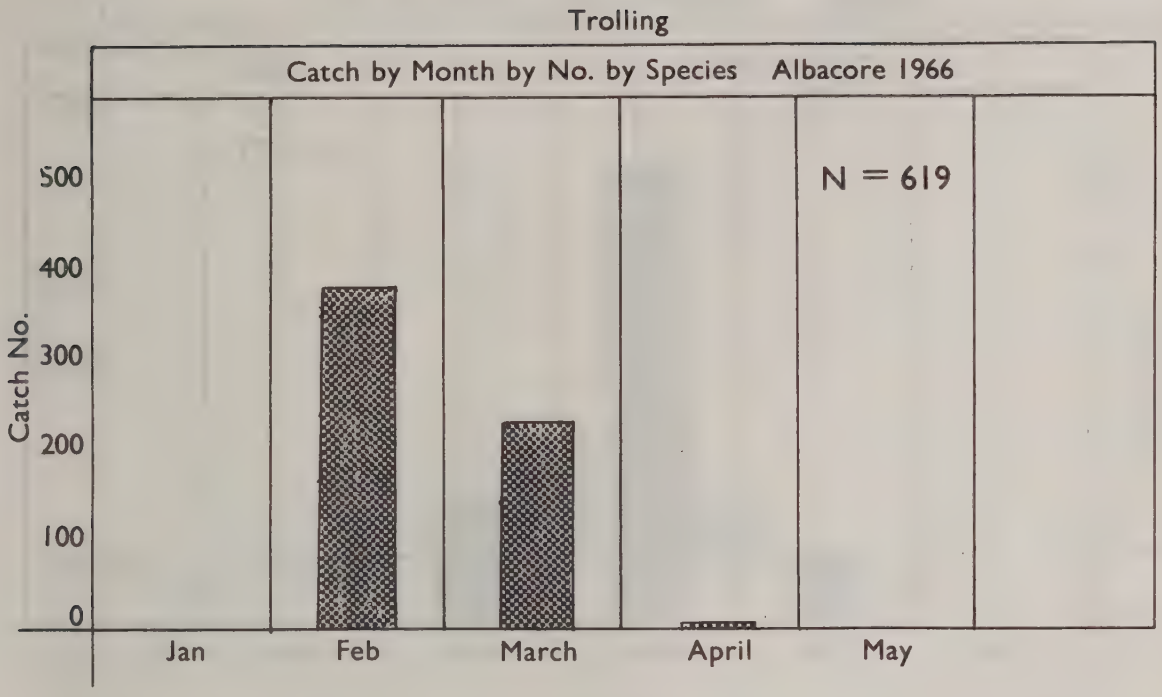
Date	Net Used No. and Mesh Size		Hours Fished	Net Hours	Catch (No. of Fish)		Fish/Net Hour	
	5½"	7½"			Albacore	Skipjack	Albacore	Skipjack
21/1	1	3	1.5	6	0	0	0	0
12/2	1	3	3.25	13	0	6	0	0.5
18/2	1	3	2.0	8	6	127	0.75	16.0
18/2	1	3	1.5	6	0	17	0	2.8
22/2	1	3	3.5	13	1	0	0.1<	0
23/2	3	0	2.25	6.75	0	0	0	0
24/2	3	0	2.75	8.25	1	18	0.1	2.2
24/2	1	3	2.75	11.0	1	7	0.1<	0.6
26/2	3	0	1.25	3.75	0	63	0	16.8
16/3	3	0	2.5	7.5	0	6	0	0.8
19/3	3	0	2.25	6.75	0	98	0	14.5
7/4	4	0	2.0	8.0	0	15	0	1.9
9/4	4	0	4.25	17.0	0	0	0	0
12/4	4	0	1.0	4.0	0	32	0	8.0
13/4	4	0	4.0	16.0	0	11	0	0.7
14/4	4	0	2.5	10.0	0	9	0	0.9
15/4*	4	0	23.0	92.0	0	9	0	1.1
24/4	3	0	1.25	4.75	0	21	0	4.4
25/4	3	0	0.5	1.5	0	0	0	0
25/4	4	0	3.0	12.0	0	112	0	9.3
26/4	4	0	2.0	8.0	0	32	0	4.0
2/5	2	0	1.75	3.5	0	3	0	0.9
2/5	4	0	1.5	6.0	0	0	0	0
7/5	4	0	3.25	13.0	0	73	0	5.6
8/5	5	0	3.0	15.0	0	6	0	0.4
9/5	5	0	4.5	22.5	0	0	0	0
TOTAL			83.0	323.25	9	665		

TABLE 11

1967 Gill-Netting in Each Area (Areas shown in Figure 3)

Catches as Number of Fish

Area	Nets Used No. and Mesh Size		Hours Fished	Net Hours	Catch (No. of Fish)		No. of Fish Net/Hour	
	5½"	7½"			Albacore	Skipjack	Albacore	Skipjack
A	14	Nil	29	113	Nil	87	Nil	0.8
B	8	Nil	5	20	Nil	43	Nil	2.1
C	15	6	12	40	2	43	0.1	1.1
D	10	9	13	43	6	182	0.1	4.2
E	31	Nil	22	86	Nil	310	Nil	3.6
F	1	3	4	14	1	Nil	0.07	Nil



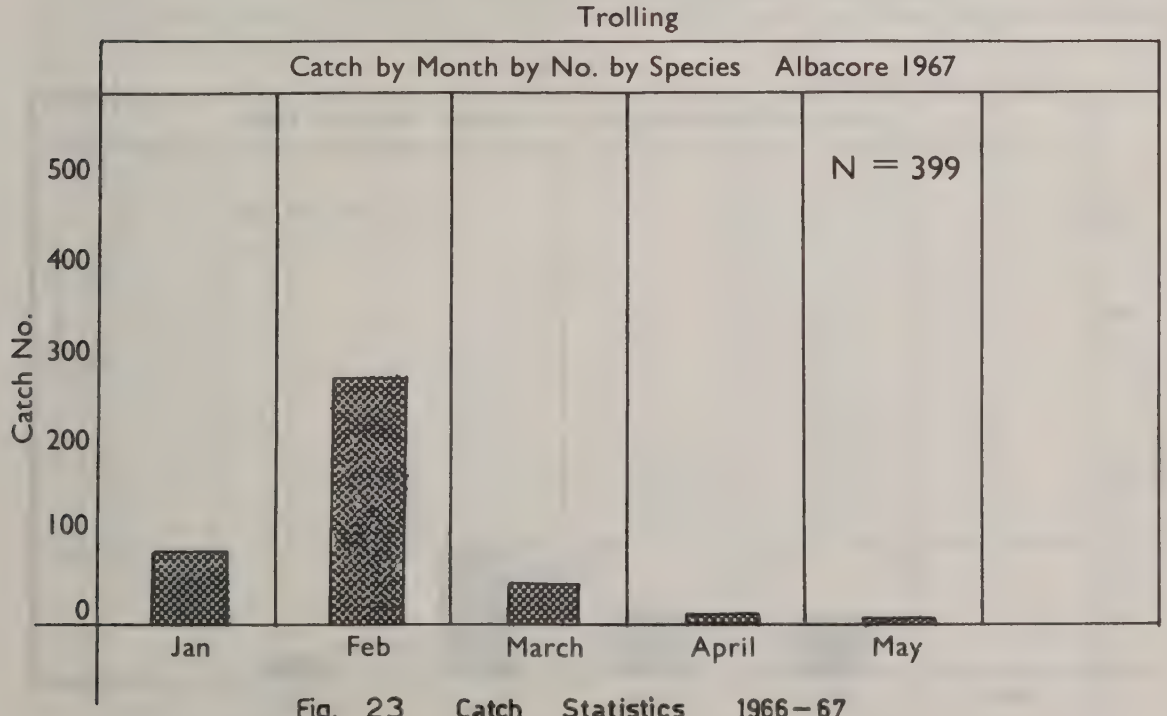
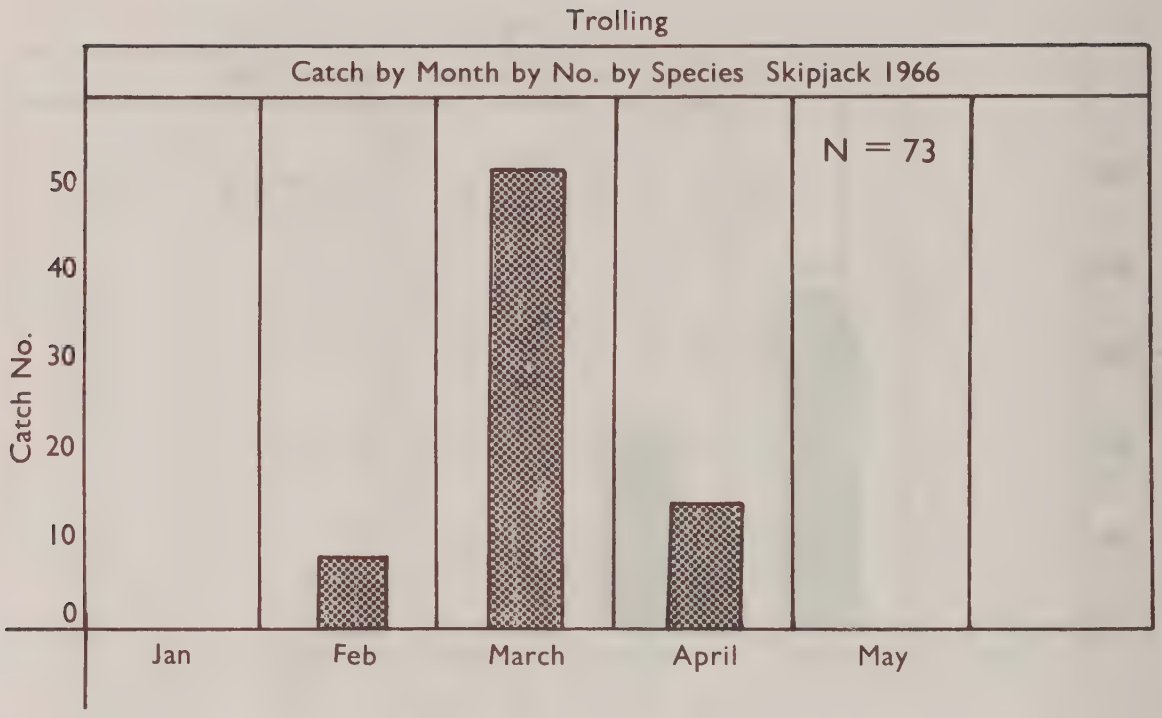


Fig. 23 Catch Statistics 1966–67



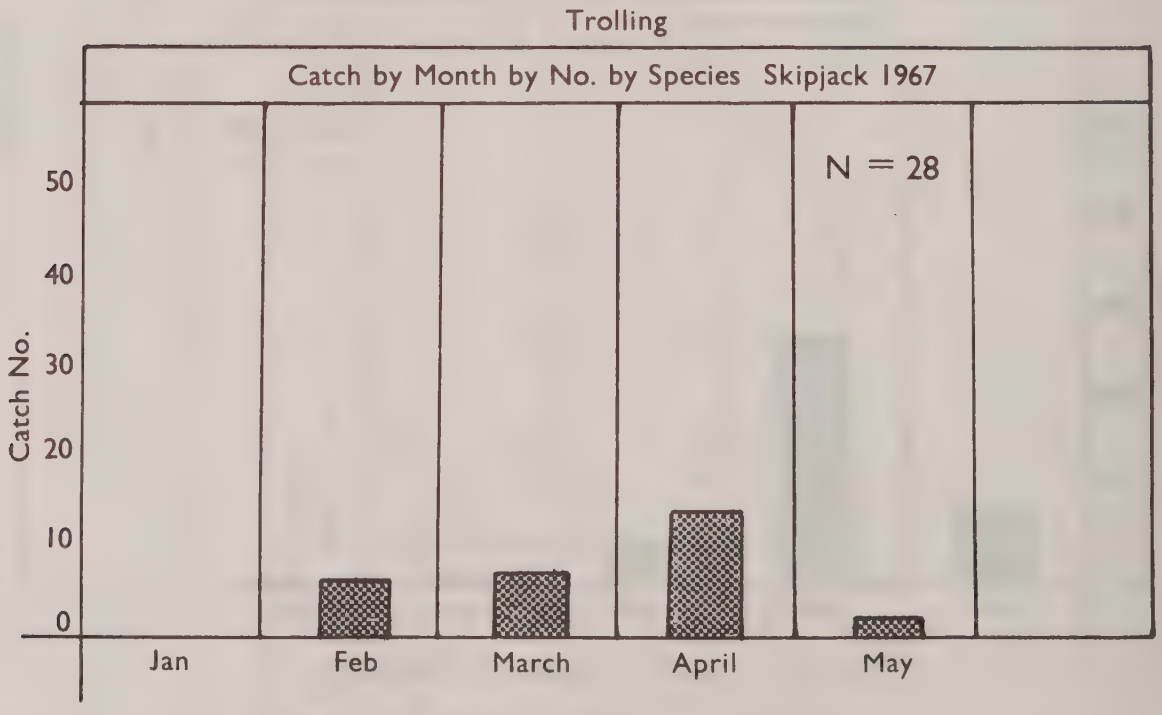
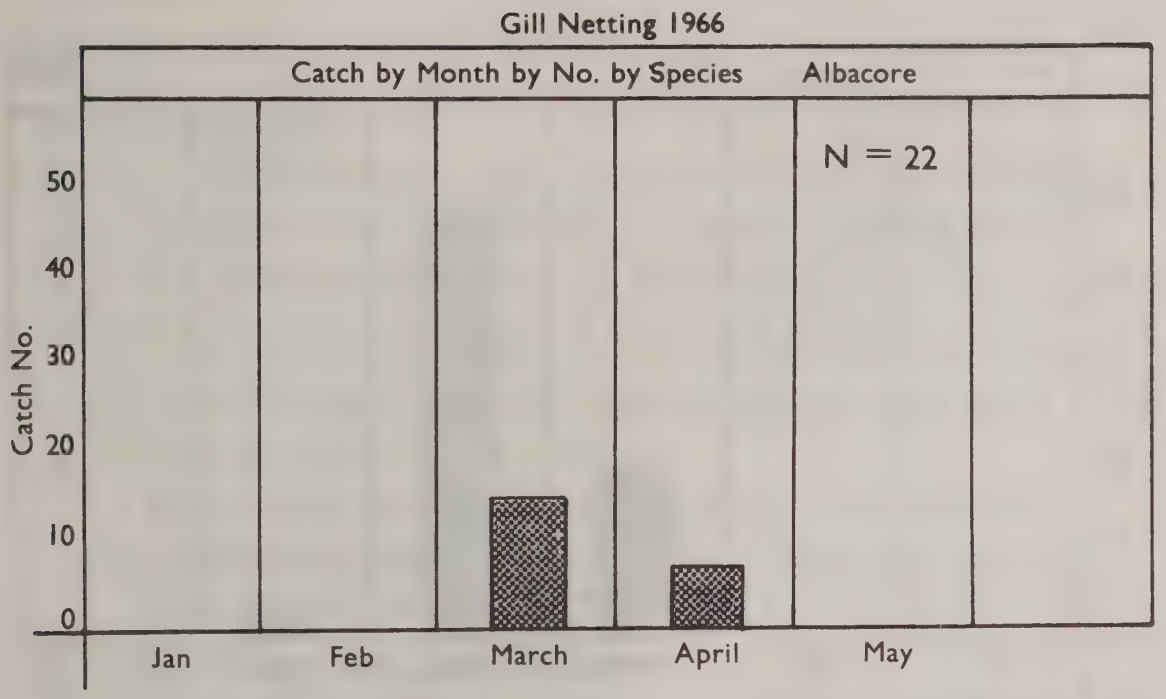


Fig. 24 Catch Statistics, 1966–1967



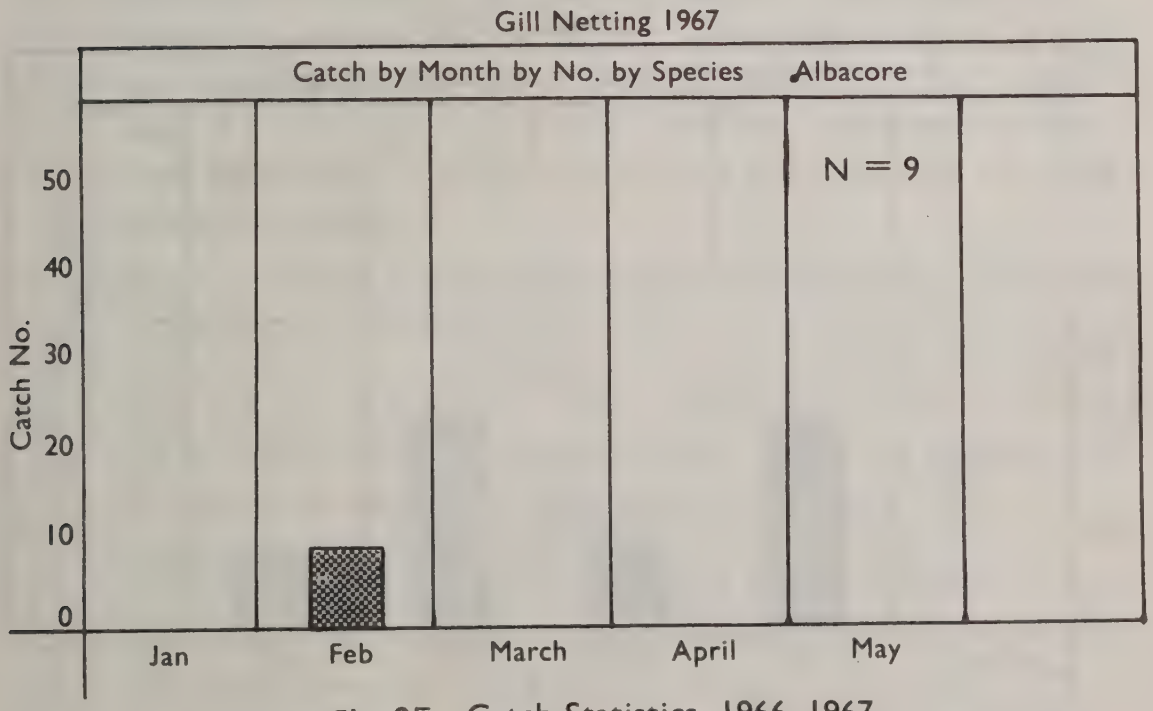


Fig. 25 Catch Statistics, 1966–1967

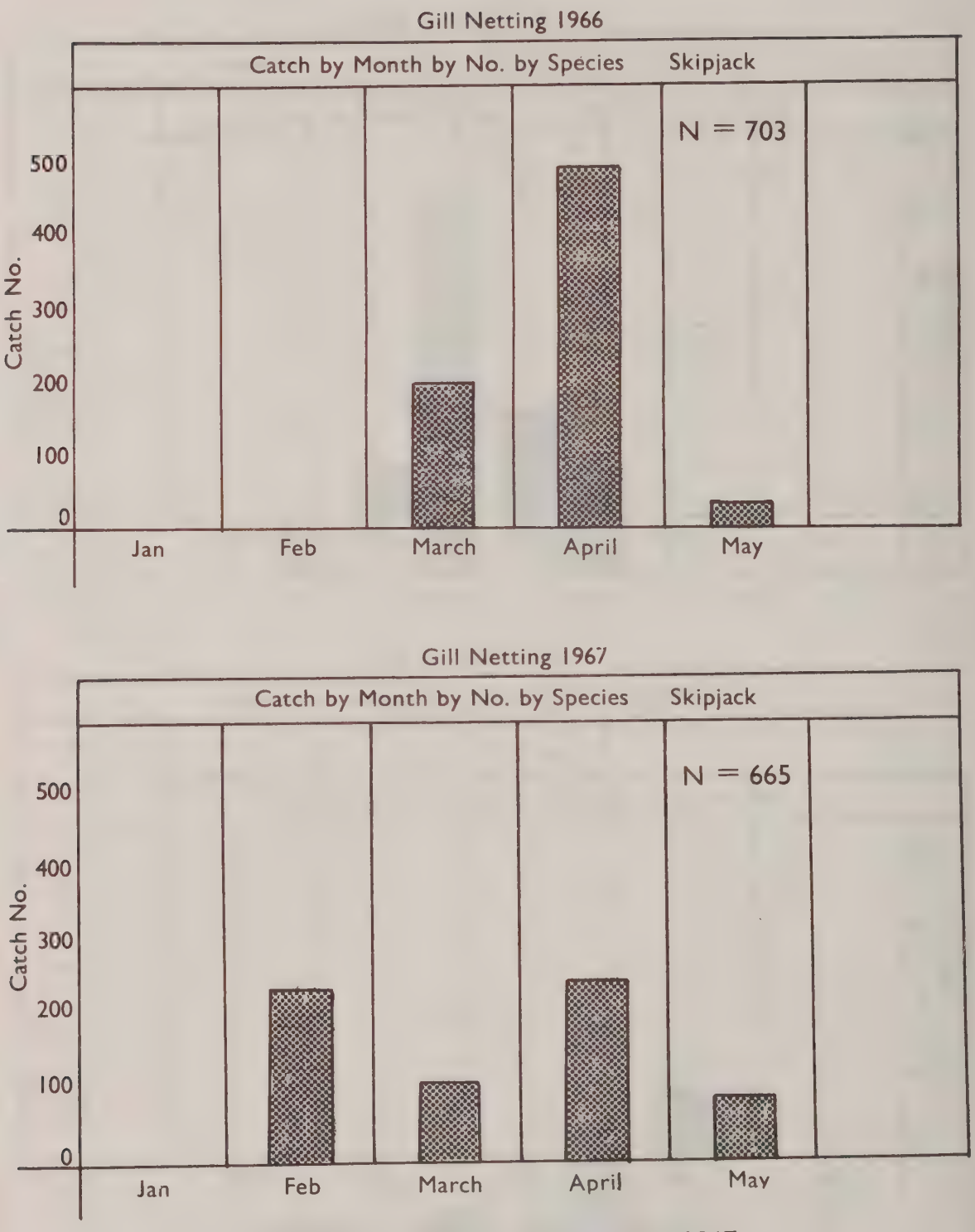


Fig. 26 Catch Statistics, 1966–1967

FISH

(a) Population

It is not known to which population the albacore and skipjack which migrate to New Zealand waters belong. The albacore may belong to the South West Pacific population described by Kurogane and Hiyama (quoted in F.A.O. (1963)). Comparison of meristic characters of New Zealand fish and populations in other areas are made in Tables 12 to 14.

About 5% of the skipjacks were pale in colour with indistinct lateral bands. Similar fish are recorded from Minicoy Island in the Laccadive Sea (F.A.O. 1963).

(b) Occurrence and Distribution

Migratory yellow fin, albacore and skipjack appear near the Bay of Islands in late November. They are often associated with the region of upwelling shown in Figure 1. This upwelling and its association with the appearance of tuna and bill fishes has been observed by big game fishermen for many years and was observed by the author in 1965.

Surface schools of skipjack are usually about 200 yards long, but occasionally schools several times larger than this were seen. Skipjack were usually most abundant in April-May. However, in 1967 the largest catch was made in February when the skipjack were observed feeding on a school of anchovies (Engraulis australis), in exceptionally clear water 7-10 fathoms below the surface; under normal conditions these skipjack would not have been sighted. A more recent occurrence of skipjack early in the year was when in February 1968 a Gisborne vessel caught about a ton of skipjack when purse-seining for kahawai (Arripis trutta), although there were no indications that tuna were in the area.

It is possible the skipjack are present in quantity early in the year but do not school on the surface until hydrological conditions are suitable and bait fish on the surface. Sono Buoys could be used to detect

TABLE 12

Meristic Features : Albacore

Gill Raker Counts - Upper and Lower Limbs of gill arch and total rakers

		Upper Limb				Lower Limb					Combined						
Number of Rakers		7	8	9	10	18	19	20	21	22	25	26	27	28	29	30	31
Locality	Number of Fish Measured																
Japan*	8		3	5			1	5	2				1	1	5	1	
California*	11		2	8	1		1	7	3					2	6	3	
Indian Ocean*	38	1	12	25			7	20	10	1			5	9	15	8	1
Northwest Pacific*	102	2	38	58	4	4	14	59	24	1	1	1	8	32	44	12	3
Southwest Pacific*	127	5	52	66	4	1	23	71	29	3		2	14	41	45	23	2
New Zealand	110	2	45	58	5	1	36	59	10	4		1	7	41	53	8	

* Data from F.A.O. (1963)

Albacore and Fin Ray and Finlet Counts

		Fin Rays						Finlets			
		1st Dorsal		2nd Dorsal		Anal		Dorsal Finlets		Anal Finlets	
Number		13	14	15	16	14	15	7	8	7	8
Locality	No. of Fish Examined										
Japan*	9		9	4	5	2	7	6	3	8	1
California*	11	3	8	4	7	1	10	8	3	10	1
New Zealand	35	1	34	3	32	3	32	9	26	18	17

* Data from F.A.O. (1963)

TABLE 14

Skipjack, Gill Raker, Fin Rays and Finlet Counts

Locality	1st Dorsal	2nd Dorsal	Anal	Dorsal Finlets	Anal Finlets	Combined Gill Rakers
Japan*	14-17	13-15	13-15	8-10	6-9	36-41
East Pacific*	15-16	14-15	14-16	7-8	6-8	35-43
New Zealand	15-16	14-16	14-16	7-8	7	35-43

* Data from F.A.O. (1963)

the presence, size and depth of swimming of schools early in the year. But depending on depth of swimming other gear might have to be used at this time.

In general quantities of skipjack were not seen after May and albacore were not present in quantity after mid-April. The distribution and abundance of albacore and skipjack in each year was different and is therefore discussed for each year in turn.

(i) Figure 27 shows the distribution of tuna in 1965. During February, scattered schools of albacore and skipjack were observed in the Tokomaru Bay, Waiapu River and Cape Runaway areas. In March scattered schools occurred along the coastline from the Ariel Banks to the Bay of Plenty, concentrated schools of albacore were present in the eastern Bay of Plenty and off Cape Runaway and concentrated schools of skipjack were encountered in the Gable End Foreland and Waiapu River areas in early April, scattered schools of both species were present all along the coast but by the end of the month the off-shore migration had started.

(ii) Figures 28 shows the distribution of tuna in 1966. Between mid-February and the end of March, scattered schools of albacore and skipjack were feeding mainly in the Ariel Banks, Tokomaru Bay and Hicks Bay areas, whilst concentrated schoolswere found in the vicinity of the Ariel Banks and the Waiapu River, with small concentrations off Tolaga Bay, East Cape and Cape Runaway.

During April and early May, large concentrations of skipjack were found in the Ariel Banks and Gable End Foreland areas, and small concentrations off the Waiapu River, eastern Bay of Plenty and Cape Runaway areas. Very thinly scattered schools of both species occurred all along the coastline.

(iii) 1967

Figure 29 shows the distribution of tuna in 1967. In 1967 the first signs of albacore were observed in the Ariel Banks to Tokomaru Bay area in early January, but adverse weather prevented observations further north. In mid-January observations were confined to Gisborne-Tolaga Bay, and only scattered albacore were seen. In late January tuna were seen in the eastern Bay of Plenty. During February concentrated schools of albacore were feeding between Tokomaru Bay and East Cape, but mainly off the Waiapu River. Owing to adverse weather and mechanical failure to the vessel only a few days were spent in the eastern area of the Bay of Plenty in February and only small concentrations of albacore were seen.

On 12 February at the soutern end of the Tokomaru Reef, although there were no "signs" of the fish, the first skipjack were caught, meshed in the gill-net at approximately 5 fms. depth. Several concentrated schools of feeding skipjack were found in the same area on 18 February and these schools yielded the highest skipjack catch of the 1967 season. For the remainder of February scattered schools occurred from Tokomaru Bay around the coast to the Bay of Plenty, with concentrations off the Waiapu River and in the eastern Bay of Plenty. During March and April scattered schools were encountered all along the coastline, with major concentrations at the Ariel Banks, Gable End Foreland and Tolaga Bay areas. In May the only area where tuna were caught was off Tolaga Bay. It should be noted that Figures 27-29 are compiled from observations made from only one vessel and there were probably many other areas where tuna occurred in quantity.

Salinity fronts occur where high salinities are present around pockets of outflowing low salinity river water, e.g. off Waiapu River mouth and aggregations of albacore occurred along

these salinity fronts in the three surveys; where surface salinities were stable albacore occurred as scattered schools.

Figures 15 to 22 show the surface conditions existing during the 1967 survey, the large numerals indicating the position and numbers of fish in good catches. The association of the good catches with temperature fronts is obvious, particularly in Figures 17 and 22. The typical occurrence of a large pocket of cooler water during a strong southerly set in river mouth areas is illustrated in Figure 18.

Albacore and skipjack feed by sight and usually inhabit blue waters, but off the New Zealand coast they enter and feed inshore in green and discoloured water, particularly close to river mouths where bait fish are abundant. Twice in 1966, gill nets were shot across the well-defined boundary between blue and green waters; catch-rate in the green water were 15% higher than in the blue. The highest albacore catch rates were in highly discoloured waters off the Waiapu River mouth where on one occasion 600 albacore were trolled by three vessels in five hours.

(c) Fish Size

In 1965 a total of 69 fish were measured, in 1966 186 albacore and 170 skipjack and in 1967, 116 albacore and 346 skipjack were measured. Figures 30 and 31 show the percentage length-frequency by month and species.

It can be seen from Figure 30 that skipjack length increased through the season. In 1965 the length range was 40-67 cms. (weight 2.5-12 lbs.), in 1966 from 46-72 cms. (weight 5-12 lbs.) and in 1967 was 34-73 cms. (weight 3-13 lbs.). The length range of albacore during 1965 was 40-85 cms. (Figure 31)

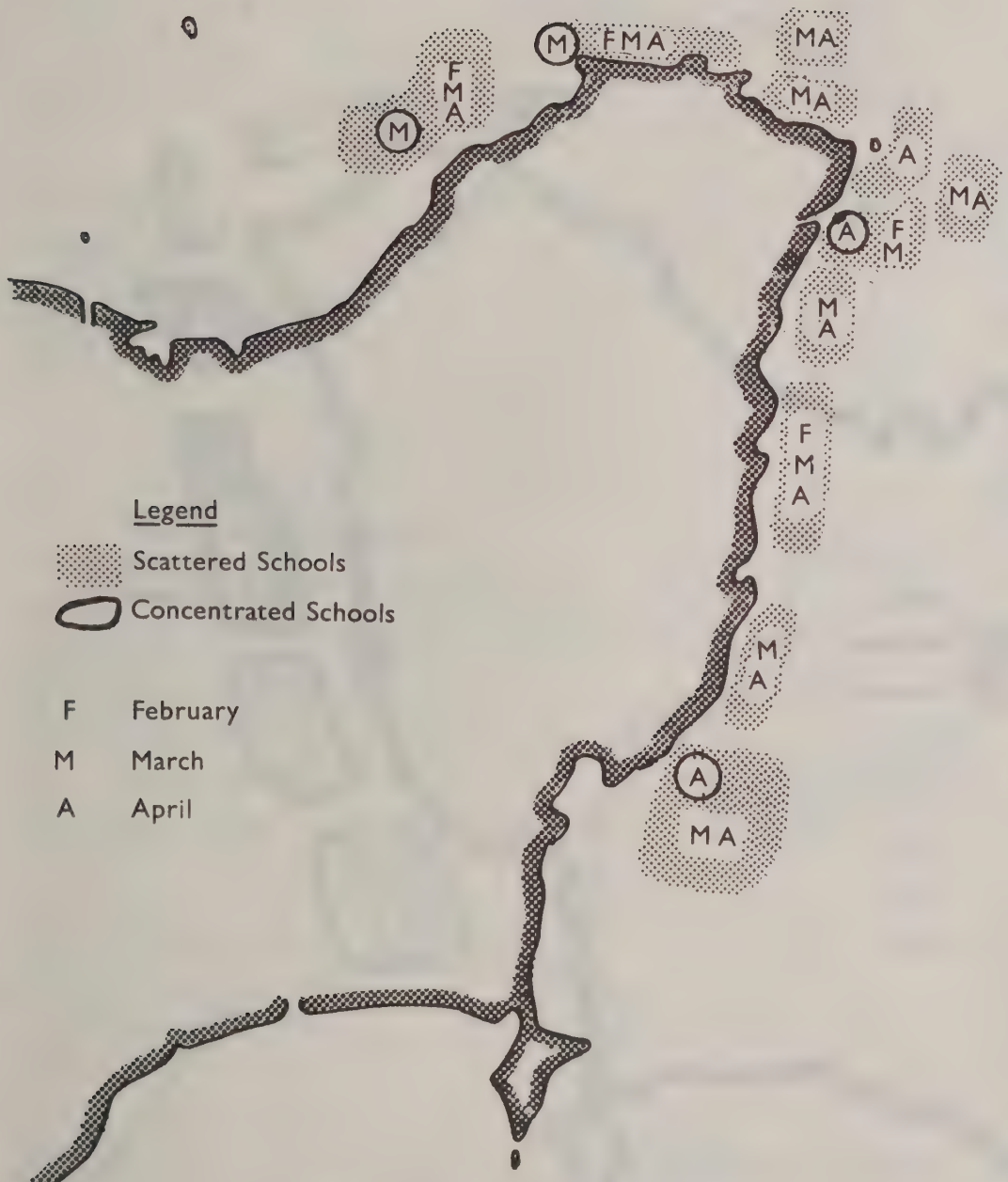


Fig. 27 Productive Areas, 1965

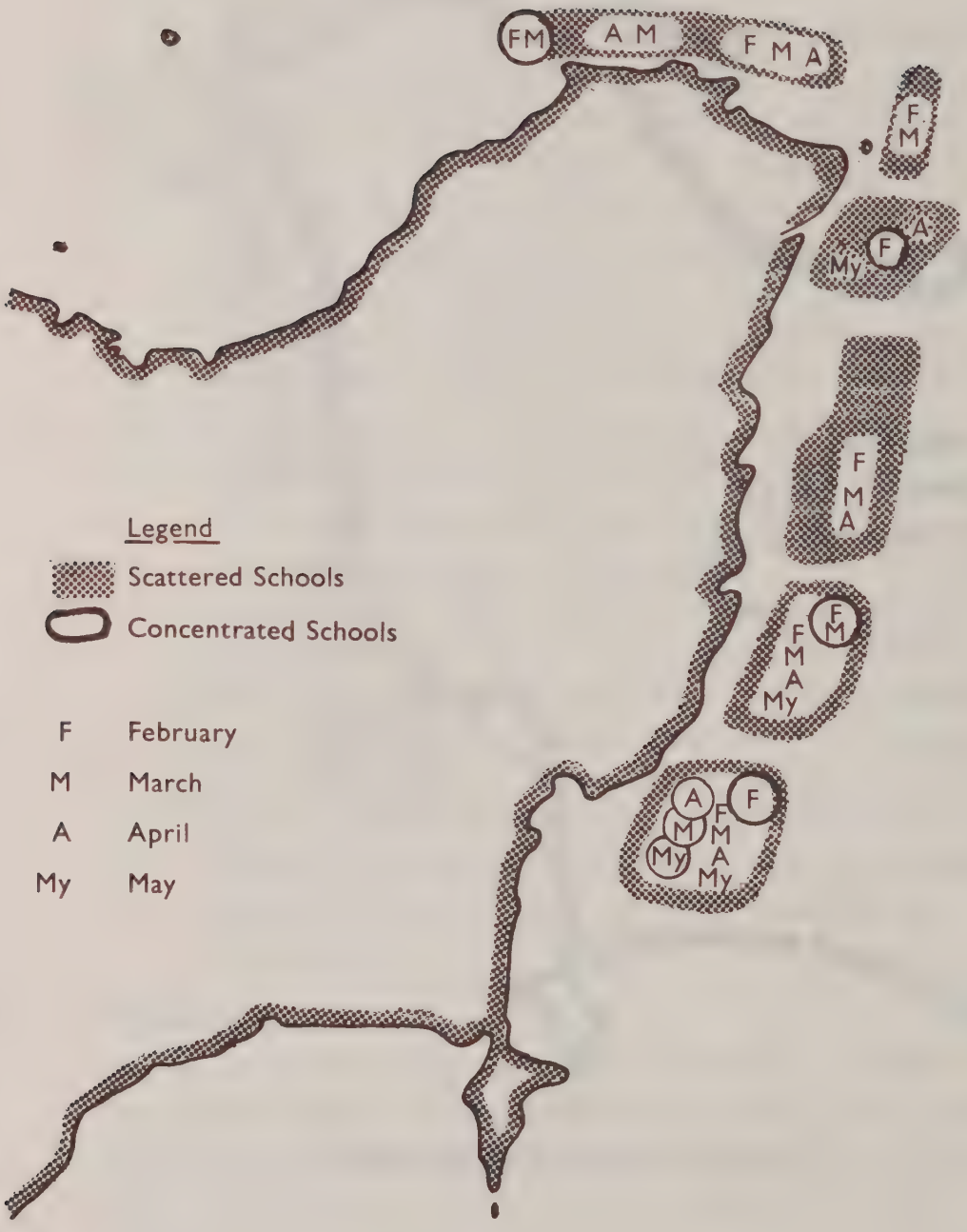


Fig. 28 Productive Areas, 1966

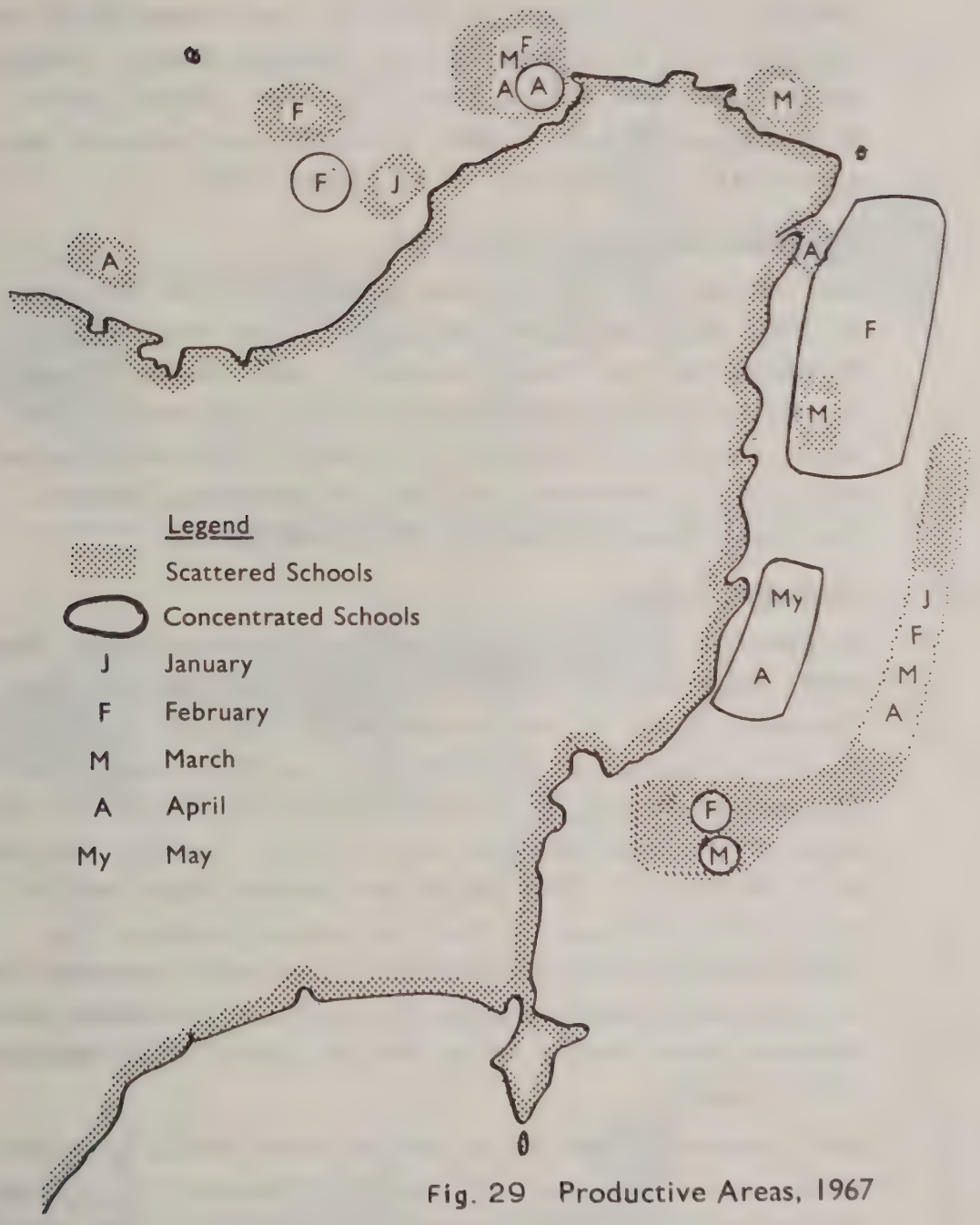


Fig. 29 Productive Areas, 1967

(weight 7.5-22 lbs.), in 1966 the range was 46-94 cms. (weight 7-25 lbs.) and in 1967 lengths ranged from 36-105 cms. and weight from 5-39 lbs. Comparisons with data in F.A.O. (1963) indicate that several year groups are included in the albacore catch.

(d) Sex and Maturity of the Catch

The catches of both species were predominantly male, e.g. in 1967 of 60 skipjack and 60 albacore sexed only 3 female skipjack and one female albacore were present. Most of the male and female albacore were immature or in early stages of maturity. The male skipjack examined were mainly immature but four had maturing testes; the three females examined were immature.

(e) Food and Feeding

In general intense feeding by both species began about three hours after sunrise and continued until midday in the early part of the season, with sporadic feeding in the afternoon up to 4.30 p.m. As the season progressed feeding was maintained until 6 p.m. by the majority of tuna schools but a little feeding continued until darkness. Throughout the season there was a noticeable decrease in feeding around midday. In 1967 trolling was carried out for a full 24 hours, but no tuna were caught during the hours of darkness although albacore were caught after the skipjack had disappeared before sunset.

The tuna eat a variety of foods, from small crustaceans (e.g. euphausids and crayfish phyllosomae) to pilchards 10 inches long. Some bottom-dwelling organisms occurred in albacore stomachs in 1967.

Table 15 shows the percentage occurrence of food items in skipjack and albacore stomachs in 1965 and 1966. Fish was the dominant food item and the anchovy (Engraulis australis) the most frequently eaten fish. Ocean piper (Scomberesox saurus), pilchard (Sardinops neopilchardus), and yellow-eyed mullet (Aldrichetta forsteri) were also eaten.

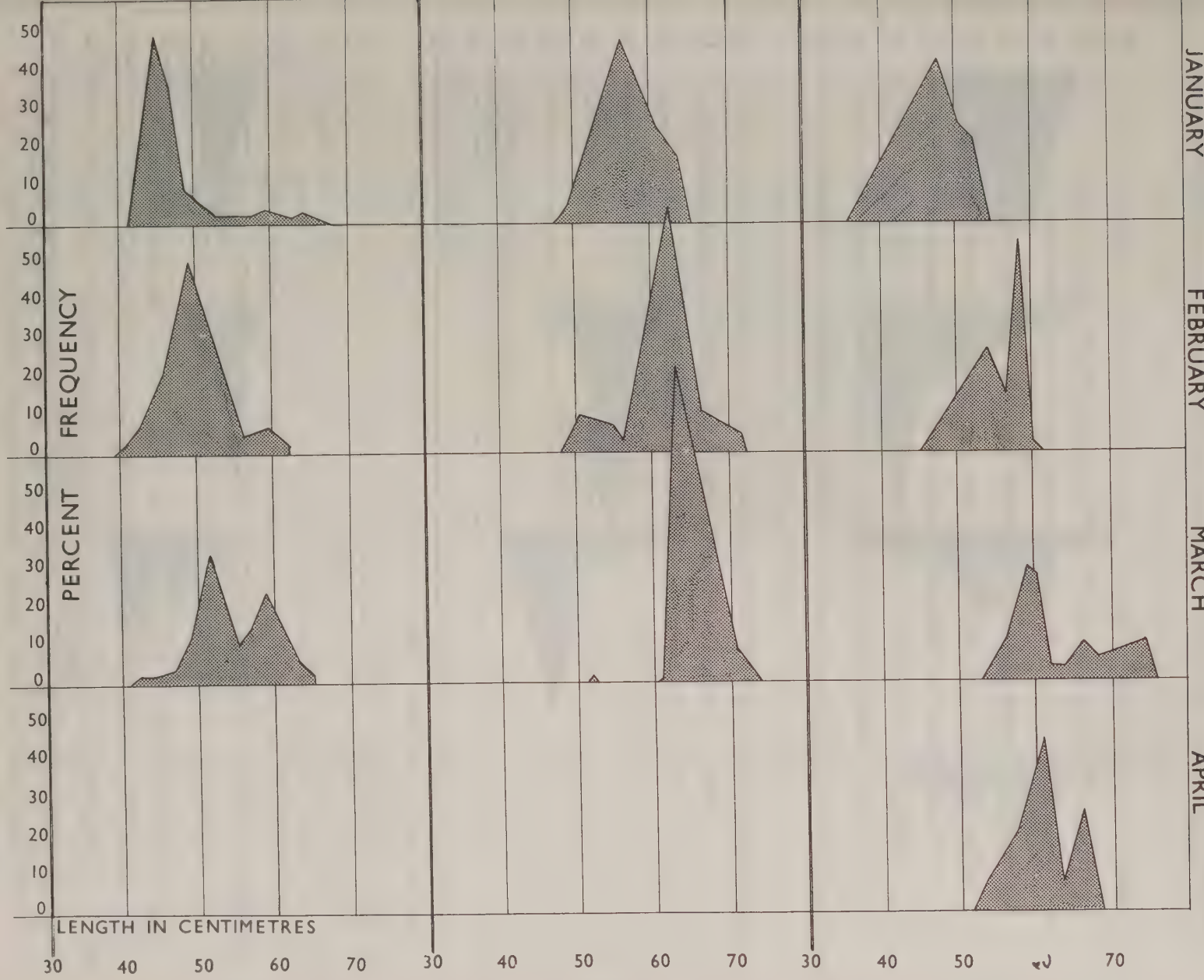
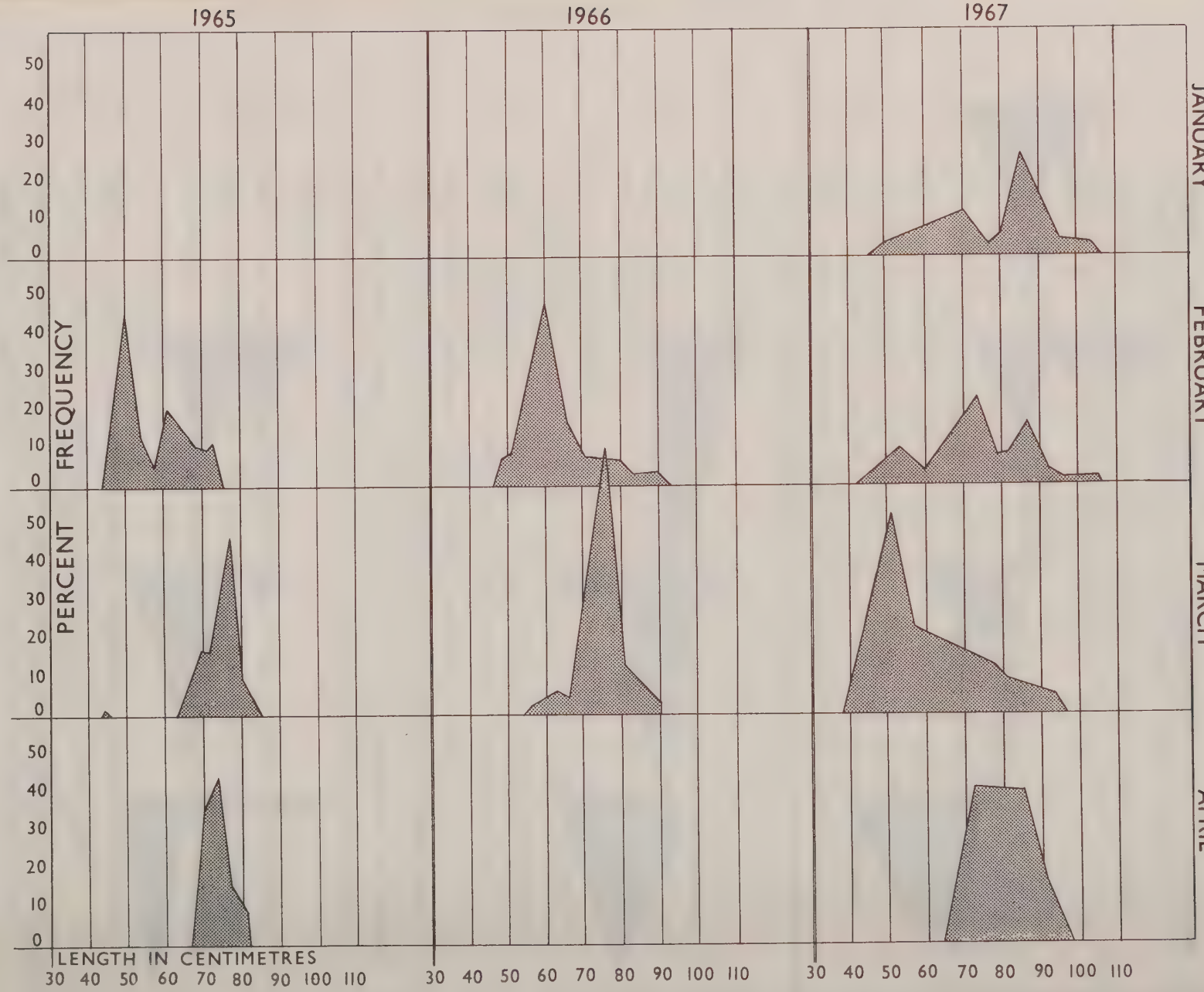


FIG. 30 LENGTH FREQUENCY SKIPJACK, 1965-1967


1965
1966
1967
JANUARY
FEBRUARY
MARCH
APRIL
FREQUENCY
PERCENT
0
10
20
30
40
50
LENGTH IN CENTIMETRES
30 40 50 60 70 80 90 100 110

(f) Association of tuna with other animals

In New Zealand waters yellowfin and bluefin tuna sometimes feed in the same areas as dolphins, but on the few occasions when albacore and skipjack were seen close to dolphins, the tuna schools quickly dispersed.

On 35 of the 120 occasions when tuna were caught by trolling or gill netting they were associated with other animals; fluttering shearwater were most frequently present followed in order of frequency by sooty shearwaters, gannets, albatross, fish schools, terns and gulls.

The best indicator of the presence of albacore or skipjack was the fluttering shearwater (Puffinus gavia gavia); these fly ahead of tuna schools, and several successful gill-net catches were made by shooting the net ahead of the shearwaters.

DISCUSSION

FACTORS AFFECTING FISHING

(a) Weather

In 1965, 47 days were spent at sea, and ten days were lost due to adverse weather. In 1966, 65 days were spent at sea, and 31 days sheltering, and in 1967, 80 days were spent at sea, 40 days sheltering and 17 days in port for engine repairs. Details are shown in Table 16. Wind direction and force was recorded each day, the data for 1966 and 1967 are included in Table 17.

In general conditions were unsuitable for trolling when the wind force exceeded 22 knots, as above 22 knots the surface turbulence exaggerated the lure movement and lure efficiency rapidly decreased. Gill netting was difficult from the particular vessels used when winds exceeded 17 knots, the seas breaking over the stern when hauling and excessive strain being put on the cork and ground lines.

TABLE 15

Food of Albacore and Skipjack as percentage occurrence of food items in stomachs.

A total of 69 stomachs were examined in 1965 and in 1966, 186 Albacore and 170 Skipjack stomachs were examined.

Year	Month	Food	% Stomachs containing food-type	
			Skipjack	Albacore
1965	February	Fish	54	61
		Crustaceans	43	33
		Cephalopods	34	28
		Salps	5	8
		Unidentified	3	4
	March	Fish	57	59
		Crustaceans	43	37
		Cephalopods	39	33
		Salps	7	4
		Unidentified	4	3
1966	February	Fish	-	77
		Crustaceans	-	19
	March	Fish	100	76
		Crustaceans	18	20
		Cephalapods	19	32
	April	Fish	65	98
		Crustaceans	63	-
	May	Fish	82	-

TABLE 16

Sea Operations 1965-1967

Year	Area	Total Period (Days	Number of Days at Sea	Days * Suitable Trolling	Days ** Suitable Gill-Netting
1965	Gisborne to Cape Runaway	57	47	36	33
1966	Gisborne to Cape Runaway	96	65	30	18
1967	Mahia Peninsula to Whale Island	137	80	61	37
	TOTAL:	290	192	127	88

Note: * Wind velocity less than 22 Kts.
** Wind velocity less than 17 Kts.

TABLE 17

Percentages of Wind Direction and Force

A 0 - 17 Knots
B 17 - 22 Knots
C Over 22 Knots

Direction	1966				1967			
	Percentage of total period			Total	Percentage of total period			Total
	A	B	C		A	B	C	
North		1	1	2	6	3	2	11
North East	5	3	15	23	4	2	12	18
East	1		6	7			5	5
South East	3	4	13	20	1	1	2	4
South		1	5	6	7	4	6	17
South West	3		19	22	5	2	6	13
West	3	1	3	7	2		1	3
North West		1	4	5	8	9	6	23
Variable	7	1		8	6			6
Total %	22	12	66		39	21	40	

Percentage Wind Force - A, B, and C Each Month

	January			February			March			April			May		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1966	-	-	-	54	23	23	29	55	16	20	17	63	3	0	97
1967	38	15	47	51	24	25	18	19	63	58	15	27	29	37	34

High percentages of wind over 22 knots occurred in February 1965, and in April and May 1966, and in January and March 1967. High percentages of winds of less than 17 knots occurred in April and May 1965, in February 1966 and 1967 and in April 1967.

During the three surveys of the 192 days at sea 88 days were suitable for gill-netting, and 127 days for trolling. But in 1967 bad weather reduced the best period for albacore off the Waiapu River to only a few days.

It was, however, sometimes possible to fish in high wind speeds close inshore in sheltered locations.

The degree of coastal shelter varied with locality and wind direction. The coast from Table Cape to East Cape (Figure 32) is sheltered from winds from north round to south-south-west. East Cape to Cape Runaway is sheltered from southeast to southwest winds, but exposed to north westerlies. Between Cape Runaway and Whale Island is sheltered from south to east-north-east winds, but exposed to winds from the northeast to the southwest.

"Lee slope winds" funnelling down a coastal cliff face often differed in direction from the main air flow and affected fishing close inshore particularly near East Cape and Cape Runaway. Frequently in 1967 for periods of several days winds were only suitable for gill-netting from early morning until about three hours after midday when winds freshened and under these conditions the vessel operated mainly from Gisborne and fishing was mainly fished between Tokomaru Bay and Ariel Bank although there were indications that albacore were present in the more northern area.

(b) Tide

Unpredictable and swift tides close to Cape Runaway, Hicks Bay and East Island areas were too strong for successful gill netting. Elsewhere attempts to fish anchored nets across the tide were unsuccessful.

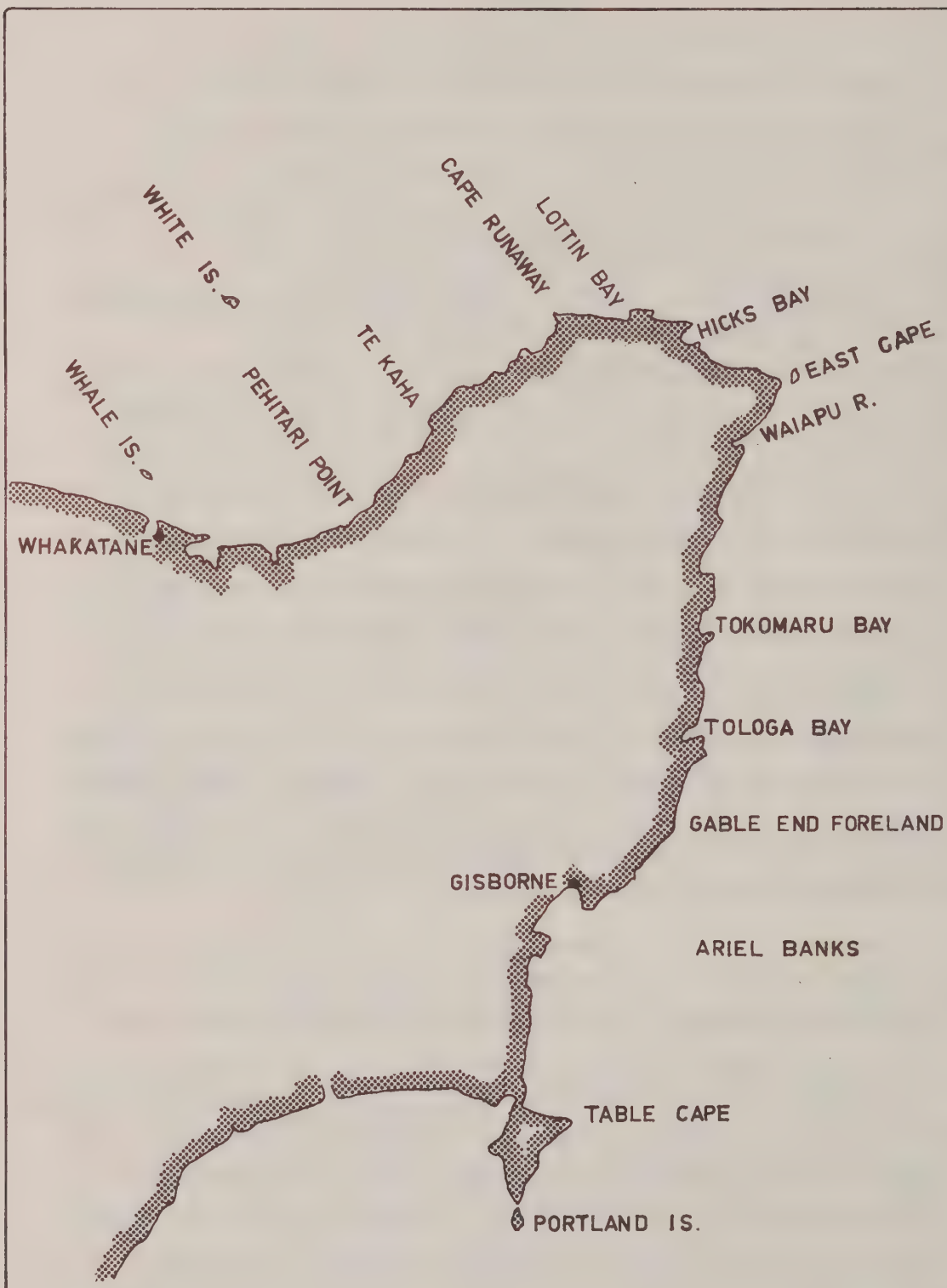


FIG. 32 COASTAL SHELTER

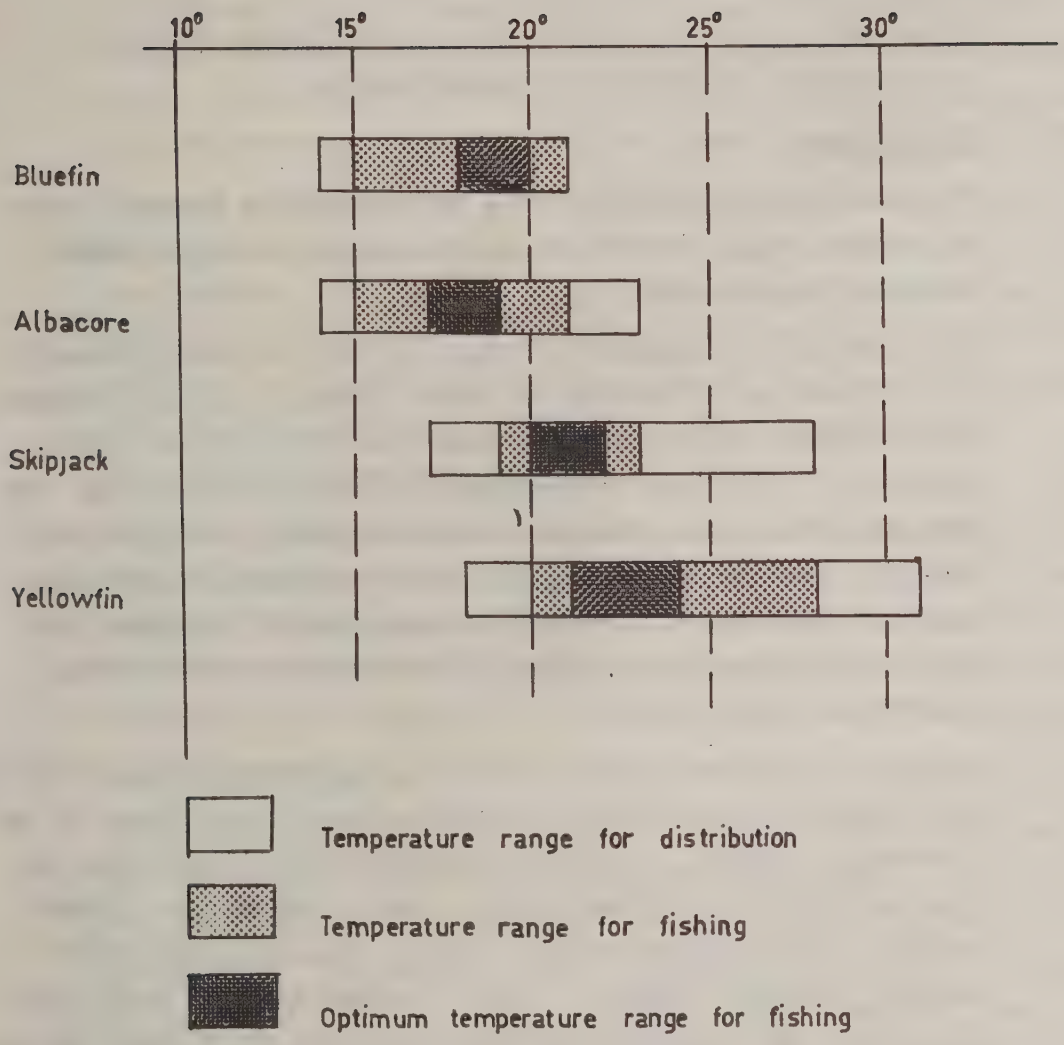


Fig. 33 Relationship between Range and Temperature in Japanese Waters, (After UDA 1952)

(c) Moon Phase

No direct relationship was observed between tuna occurrences or habit and lunar phases.

(d) Hydrology

U.D.A. (1952) described the relationship between tuna distribution, fisheries and temperature in Japanese waters (Figure 33).

The arrival of migrating tuna in New Zealand probably co-incides with that of a south flowing tongue of warm subtropical water derived from the Trade Wind Drift (Garner, 1955) and transported to the survey areas by the East Auckland Current (Brodie, 1960) and the East Cape Current (Fleming, 1950). The extent of upwelling of cold water in the Cape Reinga, Bay of Islands and East Cape areas also affects the timing of the tuna migration.

During the three years' survey, all large catches of both species were made on temperature inversions or on "thermal fronts", typical examples are illustrated in Figures 16-22. Thermal fronts were found near river mouths, or in areas where coastal dilution was very marked and were usually rich in plankton and bait fish. All large gill-netted skipjack catches were made within the narrow salinity range of 34.48°/oo - 34.76°/oo. In Hawaiian waters, skipjack fisheries are best in waters of salinity about 34.7°/oo. (Seckel and Waldron, 1960). For seven days following the hurricane"Diana" in February 1967, surface temperatures and salinities were unstable, and tuna catches very poor.

(e) Noise

In 1965, catch rates of vessels trolling with identical gear at the same speed and within a short distance of each other varied markedly. The underwater noise levels of the vessels were recorded by a Sono Buoy. Those vessels with consistently good catches had a steady

noise level but those with poor catches emitted irregular low-frequency sounds. These low-frequency sounds stemmed from loose rudders, slack shaft-bearings, etc., and correction of these faults improved catch rates. Catches were best when trolling speed was constant.

When in gill-netting a petrol engine was used to drive the hydraulic pump on the powered reel: (see page 13) the surface schools of tuna sounded rapidly when the petrol engine was started. Tuna also sounded and dispersed in response to rapid variations in main engine revolutions, but skipjack schools remained on the surface when approached at an even speed.

Several overseas research units are at present studying the effects of acoustic interference on tuna and other species; the work carried out by the New Zealand Marine Department shows the possibilities of improving fishing methods and techniques by further study in this field.

(f) Fishing Techniques

It is desirable to have a powered means of recovering gill nets but when the powered reel was used difficulty was encountered in shooting the nets quickly due to snagging of the meshes, etc. Quick shooting is crucial to this type of fishing. It took approximately three times as long to shoot from the reel as compared with free running over the stern. The most suitable fishing method for New Zealand conditions may be to shoot the nets by hand over the stern, and recover them by a puretic power block or powered, studded, roller. Gill nett catches were highest when the five nets were joined as one set.

Fishfinder records and the presence of bottom living organisms in stomachs, suggest that the use of mid-water gill-nets, fishing depths deeper than 20 fathoms, could perhaps increase catches under certain conditions and particularly early in the season.

CONCLUSIONS

The information on tuna distribution and numbers collected during the preliminary survey each year was useful to those fishermen who wished to supplement their normal fishing activities by tuna trolling.

The main conclusion to be drawn from the investigation is that albacore and skipjack occur off the north east coast of New Zealand between December and the following June, and can be exploited by gill-netting and trolling. Best catches of albacore occur in February/March by trolling and best catches of skipjack (by gill-netting) occur from February to April.

However, the gill netting catch rates show that this method would not be profitable as a sole fishing method throughout this period from the vessels used and in the area surveyed, but gill-netting, especially if shooting by hand and hauling by some powered method was used, could well prove profitable in the peak skipjack schooling period and as a secondary fishing method at other times. Trolling for albacore in areas close to river mouths (such as a Waiapu and Motu) where salinity and temperature fronts occur would also be profitable at times, e.g. on one day in February 1966 three vessels fishing a total of 20 lures for 5 hours off the Waiapu River landed 600 albacore weighing 16-18 lbs. each.

A short period of pole lining for albacore from M.V. "Olwyn" indicated that this method may also be useful in the area. Both the albacore and skipjack when schooling could be exploited by purse-seiners.

Further investigations on the association between tuna and hydrological conditions in New Zealand waters so as to allow delineating areas where tuna are most likely to occur and the development of accoustic methods of locating schools would be valuable in reducing time spent searching for the fish.

ACKNOWLEDGEMENTS

The assistance given to the Marine Department staff by the many people concerned with the project is gratefully acknowledged. Special mention is to be made of the Fishing Industry Board for provision of finance, fishing gear for the projects and also to the skippers and crews of the various vessels concerned. I am also grateful to my colleagues in Marine Department, particularly Mr D. Williamson for preparing the figures, Mr T. J. Johns, who took part in the field work, and Dr. D. Eggleston and Mr B. T. Cunningham for constructive criticism of the manuscript.

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